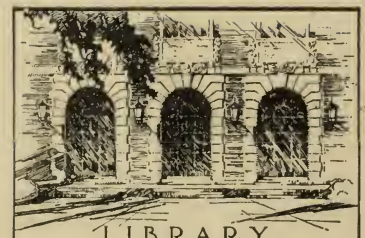

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NATURAL HISTORY
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GEOLOGY

ON THE

SUPPOSED CARNIVORA OF THE EOCENE

OF THE

ROCKY MOUNTAINS.

BY

E. D. COPE.

Extracted from the Proceedings of the Academy of Natural Sciences, Nov. 30, 1875.]

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On the supposed Carnivora of the Eocene of the Rocky Mountains.—Animals which fulfilled the functions of the existing *Carnivora* were abundant in North America during the Eocene period. The Wahsatch beds of New Mexico have yielded remains of more than a dozen species, which ranged from the size of a weasel to that of a jaguar. Investigation into the structure of these shows that while they differ in minor points among themselves, they agree in possessing characters which distinguish them from the true *Carnivora*. I have already pointed out,[1] that, in the genera *Ambloctonus*, *Oxyæna*, *Stypolophus*, and *Didymictis*, the tibio-tarsal articulation differs from that of the existing *Carnivora*, and suggested that these forms might prove to be gigantic *Insectivora*. Further investigation has satisfied me that they cannot be included in the order *Carnivora*, and their systematic position proves to be of considerable interest.

A greater or less part of the cranial chamber is preserved in specimens of *Oxyæna forcipata* and *Stypolophus hians*. In these animals it has a long, narrow form like that of the opossum, and in the first named, where the interior form can be seen, it is evident that the cerebral hemispheres were small and narrow, and that the olfactory lobes were relatively large, and were entirely uncovered, projecting beyond the hemispheres.

In *Ambloctonus*, *Didymictis*, and three undetermined forms, the femur supports a third trochanter. In all the genera the ilium has a well-marked external anterior ridge, which continues from the acetabulum to the crest, distinct from the internal anterior ridge. The ilium has, therefore, an angulate or convex external face, as in *Insectivora* and *Marsupialia*, and does not display the usual expansion in a single plane of most of the placentals. In all the genera there is a strong tuberosity in the position of the anterior inferior spine, which is wanting in the *Mammalia*, excepting certain *Insectivora* and *Prosimiæ*,[2] although it marks the position of the origin of the rectus femoris muscle in all types.

The glenoid cavity of the squamosal bone is transverse, and well defined anteriorly and posteriorly, as in the *Carnivora*. Of the first series of carpal bones of the four genera named, I have been able to learn nothing, but in the genus *Synoplotherium* from the Bridger Eocene of Wyoming, which probably belongs to this group, the scaphoid and lunar bones are separate and not united as in the *Carnivora*.

The above characters point to the *Marsupialia* or the *Insectivora* as the proper location for the flesh-eaters under consideration; and the evidence is much more weighty in favor of the latter order as their true position. For in the genera *Oxyæna* and *Didymictis* the posterior part of the inferior border of the mandibular ramus is not inflected as in *Marsupialia*, nor are the anterior inferior iliac tuberosity and third trochanter seen in that order, while both exist in the *Insectivora*.

Cuvier describes[3] the tibia of *Carnivora* as follows: "Quant à

[1] Systematic Catalogue of the Vertebrata of the Eocene of New Mexico, 1875, p. 7.

[2] See the figure of *Solenodon* by Peters, and *Chiromys* by Owen.

[3] Ossemens Fossiles, vii. p. 112.

la tête inférieure, tous les carnassiers se distinguént de l'homme par sa figure plus étroite du côte externe que le l'interne, et par sa division en deux fosses oblique, au moyen d'une arête arrondie qui repond à la partie de l'astragale. . . Le phoque l'a cependant d'une forme très-particulière par l'excessif aplatissement de sa moitié supérieure, et par sa facette particulaire inférieure, qui est en concavité simple et peu profounde."

The astragalar articular face of the tibia in the genera above named is not divided into the two oblique fossæ by "a rounded crest which is applied to the groove of the superior pully-shaped face of the astragalus." It is uninterrupted and more or less oblique in the transverse direction; always so at the posterior border. The inner malleolar process is produced downwards, and rests in a concavity on the inner side of the neck of the astragalus. The astragalus, which I have seen in several of the species, presents a corresponding trochlear face. That is, instead of a groove, it presents an open angle upwards, which separates the superior from the oblique internal face. The superior plane is flat, but is interrupted on the posterior side by a groove. This groove is the posterior extremity of that which divides the superior face of the astragalus in the higher *Mammalia*, but here it contracts to a point and disappears next the fibular face just as it reaches the superior surface. The fibular face is vertical, and shares on its posterior part a large ligamentous fossa with the opposed part of the fibula. The distal end of the fibula is remarkably stout.

This structure finds its counterpart in the internal half of the astragalus of the opossum. The arrangement permits a rotary movement of the astragalus and thus of the whole foot, on the tibia, the fibula with its fixed articulation with the astragalus, rotating on the tibia, as in the pedimanous *Marsupialia*. The flatness of the inner malleolus in some of the species indicates that the capacity for rotation was less in them than in others. This arrangement exactly reverses the extensive oblique fibulo-astragalar articulation seen in the opossum, the *Petaurista*, *Dasyurus*, etc. Prof. Owen, in describing the astralagus of the wombat (*Phascolomys*), says: "The upper articular surface for the tibia is as usual concavo-convex, the internal surface for the inner malleolus flattened, and at right angles with the preceding, but the outer articular surface presents a triangular flattened form, and instead of being bent down parallel with the inner articular surface slopes away at a very open angle from the upper surface, receiving the articular surface of the fibula so as to sustain its vertical pressure. * * * This form of astragalus is also characteristic of the Koala, Petaurists, Dasyures, and the Pedimanous Marsupialia."

In one species where the cuboid bones are preserved, it is evident that the distal end of the astragalus articulated with this as well as with the navicular bone, although the facet of the astragalus is single and continuous. As the extensive transverse distal astragalar face is characteristic of all the species where it is preserved, the contact of the cuboid and astragalus is probably common to all of this division.

The dentition of this group is consistent with its reference to

the sarcophagous *Marsupialia* or to the *Insectivora*. It has, however, decided resemblances in the form of the molars, and in the deficiency in the number of the inferior incisors, to such genera of *Insectivora* as *Mythomys* and *Solenodon*, while in the large canines, it more nearly approaches *Sarcophaga* and *Carnivora*.

I propose to include the genera *Ambloctonus*, *Oxyæna*, *Stypolophus*, and *Didymictis* in a special division under the name of *Creodonta*. This division may be regarded as a suborder of the *Insectivora*. It is possible that the genus *Diacodon* Cope belongs here also; its species resemble *Chiroptera* in the inferior dentition, and are of small size. The genus *Mesonyx*,[1] which I discovered in the Bridger beds of Wyoming, cannot be referred to the *Creodonta* as here constituted, since the trochlear face of the astragalus is completely grooved above as in the true *Carnivora*, and its distal end presents two distinct facets, one for the cuboid and the other for the navicular bones. It represents on this account a peculiar family, the *Mesonychidæ*.

To the *Creodonta* must be referred the genera *Pterodon* and *Palæonictis* of De Blainville, from the French Eocene. This author and Pomel placed them in the *Marsupialia*, but Professor Gervais remarks (Geologie et Paleontologie Française) that the evidence is insufficient for such a course. Here also doubtless belong supposed *Carnivora* from the Wyoming Eocene, stated by Marsh to be allied to the *Viverridæ*.

The remarkable type first introduced to the notice of paleontologists by Leidy, represented by the genera *Anchippodus*, *Ectoganus*, etc., has been looked upon as an order of *Mammalia* by Marsh, and termed the *Tillodontia*. He gives,[2] as its characters, the possession of claws, plantigrade feet with five toes, a third trochanter of the femur, and separate scaphoid and lunar bones. Also, that the dentition is characterized by "molars of the ungulate type," small canines, and large scalpriform incisors in both jaws, faced with enamel and growing from persistent pulps as in the *Rodentia*. He says this order "seems to combine characters of the orders of carnivores, ungulates, and rodents."

Except in the dentition, the definition above given applies to the *Creodonta;* and an analysis of the dentition shows so many points of resemblance as to render it probable that they pertain to the same order of *Mammalia*. Also, except in the dentition, the characters given by Prof. Marsh do not differ from those of the *Insectivora*. The structure of the superior molars is not inconsistent with the same order, and the small canines and large incisors are even more like those of most *Insectivora* than are *Creodonta*. The singular form of these incisors, and their growth from persistent pulps, is rather characteristic of *Rodentia*. The transverse or tubercular premolars also distinguish this group from both the *Creodonta* and the true *Insectivora*. The definitions of the order and sub-orders will then be as follows:—

[1] Ann. Rept. U. S. Geol. Surv. Terrs., 1872, p. 550.
[2] Amer. Journ. Sci. Arts, 1875, 231.

INSECTIVORA.—*Mammalia* with small cerebral hemispheres which do not cover the olfactory lobes, nor the cerebellum; with numerous clawed digits, and a third trochanter of the femur; with a transverse glenoid cavity for the mandible.

Superior incisors normal, not growing from persistent pulps; canines large; premolars compressed. Astragalus not grooved above, articulating with the cuboid as well as the navicular; five toes on the hind foot; *Creodonta.*

Superior incisors large, growing from persistent pulps, and without enamel on the sides; superior canines small when present; premolars wide or tubercular; *Tillodonta.*

These suborders of the order *Insectivora* do not differ among themselves more than do those of the *Marsupialia*, and constitute a series of parallels with them. Thus the *Creodonta* resemble the *Sarcophaga*, the *Insectivora vera* the *Entomophaga*, and the *Tillodonta* the *Rhizophaga*, typified by *Phascolomys.*

The genera of the *Creodonta* differ as follows:—

I. First and third inferior true molars without internal cusp. Last superior molar longitudinal; last inferior molar carnassial; *Ambloctonus.*

II. Inferior carnassials with interior tubercle; no tubercular molar; last superior molar transverse.

Three tubercular carnassials;[1] *Stypolophus.*

Two tubercular carnassials; *Oxyæna.*

III. Inferior carnassial with interior tubercle; a tubercular molar.

One tubercular carnassial; *Didymictis.*

The number of toes on the hind foot cannot be certainly stated in all the genera, but in *Stypolophus hians* and another species there were probably five, the inner being of reduced size. There is present in those species an ento-cuneiform bone which resembles that of *Canis;* it is compressed, with one truncate concave terminal facet, and an internal oblique one at the opposite and proximal extremity. The form of the truncate articular face of the distal end indicates the existence of an inner metatarsal bone of moderate proportions, which probably supported a small hallux. This thumb could not be opposable as in the opossum.

In general appearance the *Creodonta* differed from the *Carnivora*, in many of the species at least, in the small relative size of the limbs as compared with that of the head, and in some instances, as compared with the size of the hind feet. The feet were probably plantigrade, and the posterior ones capable of some degree of rotation. The probable large size of the rectus femoris muscle indicates unusual power of extension of the hind limb. They were furnished with a long and large tail. Probably some of the species resembled in proportions the *Mythomys* and *Solenodon*, now existing in Africa and the West Indies, but they mostly attained a much larger size. Published December 22, 1875.

[1] For the meaning of these expressions, see Syst. Cat. Eoc., New Mexico, 1875, p. 6.

ON THE

PRIMITIVE TYPES

OF THE

Orders of Mammalia Educabilia.

BY

PROF. E. D. COPE.

ON THE PRIMITIVE TYPES OF THE ORDERS OF MAMMALIA EDUCABILIA.

By Prof. E. D. Cope.

(*Read before the American Philosophical Society, April* 18, 1873.)

In the Proceedings of the American Philosophical Society, 1872, p. 554, the writer described a species of Quadrumanous Mammal under the name of *Anaptomorphus æmulus*, comparing its dental and other characters with *Simia* and *Homo*! In the American Journal of Science and Arts for November,* 1872, Prof. O. C. Marsh announced that he believed that three genera previously described by him, viz., *Thinolestes*, *Limnotherium* and *Telmatolestes*,† were referable to the Quadrumana, saying that they "have the principal parts of the skeleton much as in some of the lemurs." Prior to either of these determinations, the author described a new genus and species as allied to *Notharctus*, Leidy, under the name of *Tomitherium*,‡ but made no suggestion as to its ordinal position.

On a re-examination of the last-named genus, I am satisfied that it also should be referred to the Quadrumana, and describe it as follows:

TOMITHERIUM. Cope.

Dental formula $\frac{????}{2143}$, in an uninterrupted series. Last molars with five tubercles, others with four; all low and slightly alternating, the outer wearing into crescents. Canines quite small. Incisors very prominent, the median pair with transverse cutting edges. Symphysis coössified, projecting in front. In the molars, the adjacent horns of the two outer crescents unite with the anterior outer tubercle; the posterior outer is insignificant. There is a projection but no tubercle in front of the outer anterior tubercle. The premolars present but a single compressed conic crown; the posterior, however, widened behind, and with a low tubercle. The first and second premolars are one-rooted (not entirely a generic character).

I base the distinction between this genus and *Notharctus* on the small canine, and the sub-horizontal position of the incisors; believing that when other portions of the skeleton are studied, other differences will appear.

The portions of the skeleton of the type species preserved are: the entire dentition of the lower jaw minus the crowns of the outer incisor, canine and first premolar; the left ramus nearly complete, the extreme angle being wanting: the right humerus complete, with right ulna and radius, the latter lacking the distal extremity; a large part of the left ilium; the right femur nearly entire; part of the left humerus, metatarsals, etc.

Published October 12th 1872

* Published October 8th, 1872. † Published August 7th, 1872.

‡ ~~Read at the meeting September 20th, 1872.~~ Published August 7th 1872

The above errors caused by surreptitious alterations of the proof &

The mandibular rami are quite stout, but not very deep; the symphyseal portion long and oblique, and the coronoid and condylar portions elevated, with axis at right angles to that of the horizonal portion. The condyle is well elevated, and the coronoid process small; the dental foramen is half way between the margins of the ascending ramus, and opposite the bases of the crowns of the molars. The inferior margin of the jaw shows no tendency to inflection at a point immediately below this foramen, where it is broken off. The mental foramen is divided, the exits being at points opposite those between the premolars 1–2 and 2–3.

The humerus has a round head directed backwards and a little outwards. The tuberosities are rather small, of about equal size, and obtuse; they enclose a short bicipital groove. The bicipital crests are very largely developed, and extend to the middle of the shaft enclosing an open groove between them. The external is narrow and most elevated, the internal more obtuse and directed inwards. The shaft is thus sub-triangular in section. The distal extremity is nearly at right angles to the axis of the proximal and is much expanded transversely. A large part of this expansion is caused by the truncate internal tuberosity, and by the less prominent external one. The latter is continued in a thin ala which only sinks into the shaft at its middle. The condyles are small, the external the most prominent. There is a shallow olecranar fossa, and no coronoid, and hence no supercondylar foramen. There is an arterial foramen above the internal tuberosity.

The *ulna* is compressed, and contracts rapidly to the extremity. The olecranon is broad and obtuse and the humeral cotylus oblique to the long axis. The coronoid process is low. The shaft is remarkably curved from right to left (inwards). The *radius* has a discoidal head with central depression, and it was evidently capable of complete rotation. It exhibits a tuberosity and slight flexure below the head. The distal extremity has a horizontal triangular section with the apex internal and truncate; the shaft near it is quite flat.

The left *ilium* is obspatulate and flat, widest at the convex crest, and slightly concave on the outer side. It is rather thin, and the impression for the sacral diapophyses is elongate. The inferior border thickens gradually to the acetabulum; the superior is excised so as to form an open concavity.

The right *femur* is remarkable for its length. Its shaft is flattened from before backwards, and without flexure. The great trochanter is large, and embraces a deep in-looking fossa. There is a flat tuberosity looking outwards just below, and the little trochanter is a little below opposite to it. The condyles are sub-similar in size, the trochlear surface wide, but not flat, and the inner border thickened and considerably elevated. The femur is 1.75 times as long as the humerus; it was scarcely longer, though a small piece is wanting from the shaft of our specimen.

Remarks. Having described the more important parts of the skeleton

preserved, I now proceed to consider its systematic position, and the order to which it should be referred.

The first impression derived from the appearance of the lower jaw and dentition, and from the humerus, is that of an ally of the coati (*Nasua*). The humerus indeed is almost a fac-simile of that of *Nasua*, the only difference being a slight outward direction of the axis of the head. The same bone resembles also that of many marsupials, but the flat ilium, elevated position of dental foramen, and absence of much inflection of the angle of the lower jaw, etc., render affinity with that group highly improbable. The length of the femur indicates that the knee was entirely free from the body as in the quadrumana, constituting a marked distinction from anything known in the *Carnivora*, including *Nasua*. The round head of the radius indicates a complete power of supination of the fore foot, and is different in form from that of *Carnivora*, including *Nasua;* and finally, the distal end of the radius is still more different from that of *Nasua*, and resembles closely that of *Semnopithecus*.

We have, then, an animal with a long thigh free from the body, a foot capable of complete pronation and supination, and a form of lower jaw and teeth quite similar to that of the lower monkeys. The form of the humerus and its relative length to the femur are quite as marked as in some of the lemurs. The most marked difference is seen in the increased number of teeth; but in this point it relates itself to the other *Quadrumana*, as the most ancient types of *Carnivora* and *Ungulates* do to the more modern; *e.g.*, *Hyænodon* to the former and *Palæosyops* to the latter. In its special dental characters it shows a close resemblance to small types of the Eocene, which have been regarded as low Perissodactyles, as *Hyopsodus*, etc.

TOMITHERIUM ROSTRATUM. Cope.

Proceedings of the American Philosophical Society, 1872, p. 470.

This species was about the size of the prehensile tailed-monkey, so frequently seen in shows. The first and second premolar have but one root, the base of the second being about the size of the base of the canine. The latter are cylindric at base. The incisors form a parabolic outline, and have entire edges, the middle pair transverse ones. Enamel generally smooth, premolars somewhat striate; an indistinct inner cingulum.

	M.
Length of entire dental series (straight)	0.044
" symphysis mandibuli	.020
Depth ramus at second molar	.010
Length crown of " "	.006
Width " " "	.0045
" between two " "	.014
" " canines	.005
" of ascending ramus above dent. foramen	.016
Length of humerus	.083
Diameter of head	.013

	M.
Diameter of shaft at middle	0 0085
" " distal end, transverse	.023
" " " antero-posterior	.0078
Depth of olecranon	.009
" " ulna at coronoid	.010
Diameter extremity of radius, proximally	.009
" " " distally	.010
Length of ilium from acetabulum	.042
Width near crest	.017
Length of femur preserved	.137
Width just below neck	.017
" at middle	.011
" " extremity	.019
" of trochlea	.009
Longest chord of condyles and trochlea	.019

The remains of this species were found together by the writer in the Bridger beds on Black's Fork, Wyoming.

ANAPTOMORPHUS. Cope.

Proceedings of the American Philosophical Society, 1872, p. 554.

This genus is represented by the left ramus mandibuli of a single species. The posterior portion is broken away, and the teeth remaining perfect are the P. M. 2, and M. 1 and 2. The ramus, though small, is stout, and deeper at the symphysis than at the last molar. What appears to be the dental foramen is nearly opposite the bases of the crowns of the molars. The mental foramen issues beneath the first premolar.

Dentition of the *ramus* mandibuli, In. 2, C. 1, P.M. 2, M. 3, total, 16. It differs in many respects from these; there is no interruption in the series near the canine, and the symphysis, though massive, is not coössified. Further details are, the last molar is three-lobed and elongated behind. The composition of the crowns of the preceding molars consists of four opposed lobes, which are very stout, and connected transversely by a thin ridge behind, or in close contact in front. The premolar tooth which is best preserved, is a perfect second, which, while having two roots, possesses a crown which stands almost entirely on the anterior, presenting a curved sectorial crest forwards and upwards.

The dentition is more decidedly quadrumanous in this genus than in the last, and it might be referred decidedly to *Lemuridæ* were it not for the unossified symphysis. It no doubt represents a distinct group or family from *Tomitherium*, and one more nearly related to the existing types of Madagascar and South Africa.

ANAPTOMORPHUS ÆMULUS. Cope, loc. cit.

This species was about as large as a marmoset or a red squirrel. The enamel of the teeth is entirely smooth.

Measurements.

	M.
Length dental line	0.0148
" of last molar	.0030
" " ante-penult	.0025
Width " "	.0020
Length of three molars preserved	.0070

From the Bridger Beds of the upper valley of Green River.

On the Phylogeny of the Mammalian Orders. So much light is thrown on this subject by the researches into the structure of the fossil mammalia of the Eocene formation, that it seems opportune to call attention to the subject. I deem it demonstrated to a certainty, that the case with the mammals of this formation is the same as with the reptiles of the Trias, *i.e.*, that the family types are all more generalized, and the orders not nearly so widely distinguished as in later periods of the world's history.

The succession of forms which has terminated in the horse, has been clearly pointed out by Prof. Huxley, as well as the line which has given the world the beautiful order of the *Artiodactyla;* but the approximate lineal predecessors of the *Proboscidia*, of the Ungulate animals as a whole, of the *Quadrumana* (including man), and of the *Carnivora*, have not been clearly pointed out.

The genus *Eobasileus* has been shown* to be a Proboscidian which combines some important features of the *Perissodactyla* with those of its own order, thus standing in antecedent relation to the elephants, etc., of the present day. The number of such characters was shown to be somewhat increased in *Bathmodon*, which therefore stands still nearer to the common point of departure of the two orders. This point is to be found in types nearer the clawed orders (Unguiculata), in the number of their digits (4–5), and in which the transverse and longitudinal crests of the molar teeth are broken up into tubercles more or less connected, either type of dentition being derived according as such tubercles are expanded transversely or longitudinally. We have several genera which answer this description so far as the teeth are concerned, but unfortunately the digits are unknown; such are *Oligotomus*, *Orotherium*, etc.

The type of *Tomitherium* already described, evidently stands between Lemurine monkeys and such small allies of *Palæotheriidæ*, with conic-tubercular teeth, and which abound in the Eocenes of Wyoming and France. The dentition of the two types is indeed but little different in the Quadrumanous and Ungulate types respectively, being a continuous series of I. 2 or 3; C. 1, P.M. 3–4; M. 3; the canines but moderately developed.

A comparison with *Nasua* reveals no distant affinity. As above remarked, the fore-limb presented a great similarity in this genus and *Tomitherium*. The teeth, though less numerous, in the molar series have

* On the Short-footed Ungulata of Wyoming, page 3.

the cutting type anterior and tubercular posterior, in both genera. *Notharctus*, Leidy, resembles *Nasua* still more than does *Tomitherium*, and occurs in the same Eocene strata. Prof. Leidy originally regarded it as a Carnivore, and subsequently (Hayden's Survey Montana, 1871) placed it among Ungulates. He was probably nearly correct on both occasions, and that only a technical line will ultimately decide whether it be not a monkey.*

But the genus which associates more definitely the orders *Carnivora* and *Quadrumana*, is the *Cercoleptes*, which F. Cuvier† placed between the two. Its two cutting premolars and three true molars, with the co-össified rami of the mandible are truly Quadrumanous features, although it should on other grounds be regarded as a plantigrade carnivore. Several of the extinct genera of the Wyoming Eocene will prove to be allied to this form.

Cercoleptes does not, however, present us with the *ultimate* original type of the *Carnivora*. Such a type must also generalize the seals, with their longitudinal, cone-bearing molars, and flat, fissured claws. Some of the seals also unite the scaphoid and lunar bones later in life than other *Carnivora*, hence we would reasonably look for the division of these bones in their predecessors. The flat-clawed genera of Wyoming‡ answer these demands. The genera *Mesonyx* and *Synoplotherium* presents us with a series of molar teeth which repeat each other in form, are compressed below, and bear conical cusps. The jaws in the latter genus are slender, and the canines tend to the great development seen in many seals; but principally, the scaphoid and lunar bones are distinct, and the claws flat and widely fissured. The tympanic bone is more like that of the bear, and some seals, than that of the digitigrade Carnivora. These genera, though probably good swimmers, were well removed from the seals in the structure of the long bones of the limbs, and were probably remote in their ancestry.

In *Oligotomus*, *Orotherium*, *Hyopsodus* and similar forms, the conic tubercles of the lower molars have a slight alternation, and the posterior, which has a crescentoid section in wearing, inclines to connection with both the inner conic tubercles by low ridges. These ridges are fully developed in *Palæosyops* so that we have a dental crest of two Vs, in the inferior molars. This in wearing produces the two crescents of *Palæotherium*. The addition of two tubercles on the inner side takes place in the higher forms, which terminates in the four crescent-bearing molars of the Ruminants. How this is done is proven later by examples from the maxillary teeth. In *Orotherium vasacciense* there is a tendency for the conic tubercles to be connected in pairs by low cross ridges. These ridges fully developed produce the two cross-crests of *Hyrachyus* and *Tapirus*. In *Rhinocerus* the outer portion retains a crescentoid form, giving rise to an

* Dr. Lockwood, of Rutger's College, in a recent number of the Popular Science Monthly, expressed serious suspicions of the Quadrumanous relationships of the Coati, little thinking at the time that the specimens to confirm his view were at that moment in the hands of palæontologists.

† Dentes des Mammifers, p. 31.

‡ See the Flat-clawed Carnivora of Wyoming, by E. D. Cope, April, 1873.

L-shaped crest. In *Bathmodon* diagonal ridges appear which would result in two Vs, as in *Palæosyops*, were it not that both transverse and oblique elements of the posterior V disappear, leaving but one such in the middle and posterior part of the maudibular series. In *Uintatherium* the diagonal from the posterior crest never appears, leaving a transverse crest and a V on the true molars.

In the superior molar series the flattening of the outer tubercles may proceed so far as to produce on wearing a confluence of the crescentoid surfaces. This is the case in *Orotherium sylvaticum* in the maudibular series. In both *Palæosyops* and *Hyrachyus* those tubercles of the upper molars are confluent into two Vs (more or less open, when unworn). In the former the inner tubercles retain their primitive conic tubercular form, but in *Palæotherium*, *Rhinocerus*, *Lophiodon*, *Hyrachyus* and *Tapirus* they elongate transversely so as to meet the corresponding outer tubercles (now crests) forming the familiar cross-crests of those genera. If the tubercles are alternate, they produce the oblique crest of *Palæotherium*, if opposite, the cross-crest of *Tapirus*.

If on the other hand the inner tubercles flatten like the outer, on wearing, we have the quadricrescentoid type of *Anoplotherium* and the Ruminants.

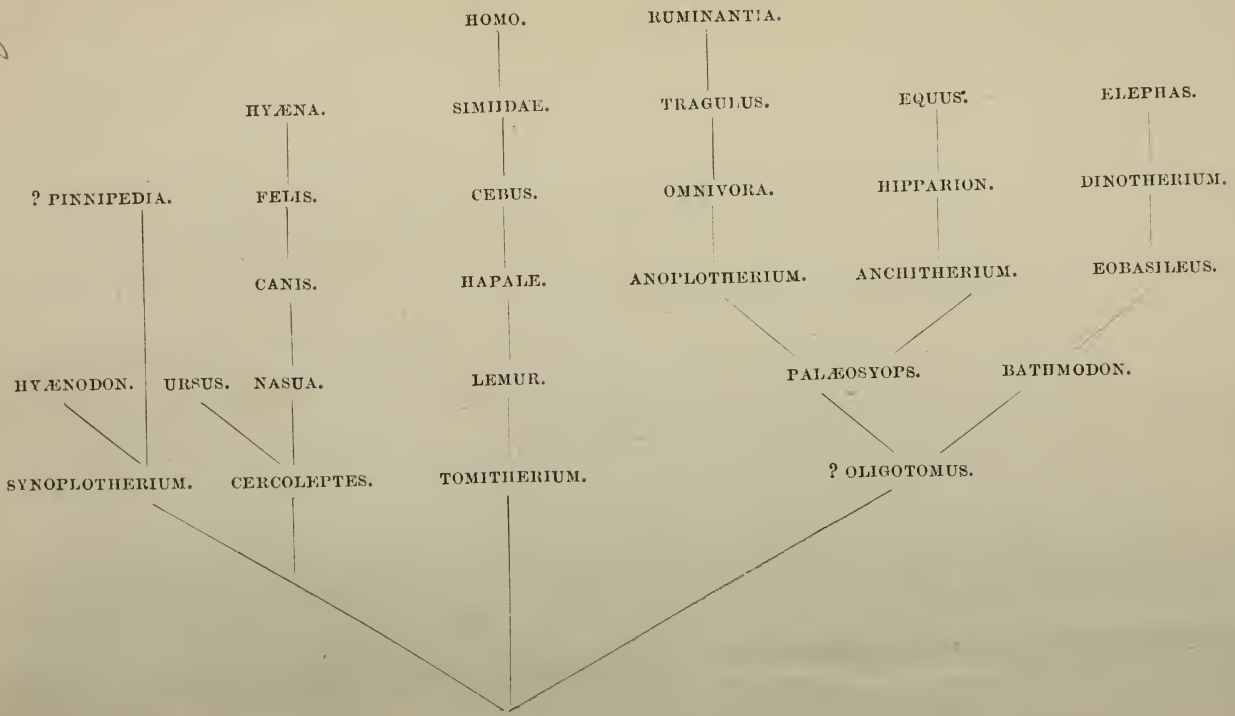
But it is important to observe, that the lower types of *Quadrumana* and *Carnivora* present the quadrituberculate crown with tendency to flattening of the outer tubercles, as seen in these lowest *Ungulata*. In the *Carnivora* the sectorial tooth is produced by the greater flattening and partial confluence of the outer tubercles, and the *entire loss* of the inner, the "heel" being in the dogs and cats, *e. g.* their only representative. In the Quadrumanous families, including man, the primitive quadrituberculate type of molars is preserved, the flattening of the outer tubercles being finally lost.

It is to be observed that the lines of *Ungulata*, *Quadrumana*, *and Carnivora*, originate in plantigrade types, a state of things quite predominant among the lower series, or *Lissencephala*. It is universal in *Edentata* and very usual in *Rodentia* and *Insectivora*. The lower forms of *Marsupialia* and all of the *Monotremes* present it. In the Marsupials, Rodents, Ungulates, and Carnivores we have series whose highest expression is in the most highly digitigrade genera.

The accompanying diagram is designed to express to the eye more clearly the propositions made above. By comparing it with a similar table published by Prof. Gill (Proceedings of the American Association for the Advancement of Science for 1871, p. 295), a close resemblance between the two may be observed, as well as certain differences.

I wish to be understood that the genera named in it as ancestors, are to be regarded in the light of types of groups. There is no other mode of explaining the facts, than that in accordance with the law of "homologous groups," *i. e.* that several genera of one group have undergone similar modification into corresponding ones of a second group.*

* See Origin of Genera, page 79, Prop. V.


HOMO.
RUMINANTIA.
HYÆNA.
SIMIIDÆ.
TRAGULUS.
EQUUS.
ELEPHAS.
? PINNIPEDIA.
FELIS.
CEBUS.
OMNIVORA.
HIPPARION.
DINOTHERIUM.
CANIS.
HAPALE.
ANOPLOTHERIUM.
ANCHITHERIUM.
EOBASILÆUS.
HYÆNODON.
URSUS.
NASUA.
LEMUR.
PALÆOSYOPS.
BATHMODON.
SYNOPLOTHERIUM.
CERCOLEPTES.
TOMITHERIUM.
? OLIGOTOMUS.

PALÆONTOLOGICAL BULLETIN, No. 33.

ON SOME MAMMALIA

OF THE

LOWEST EOCENE BEDS OF NEW MEXICO

By E. D. COPE.

(*Extr. Am. Phil. Soc.*)

(Read before the Amer. Philosophical Society, Sept. 17, 1881.)

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On some Mammalia of the Lowest Eocene beds of New Mexico. By E. D. Cope.

(*Read before the American Philosophical Society, Sept. 17, 1881.*)

Mesonyx navajovius, sp. nov. Smaller than the two known species, and with the crowns of the molars more compressed and the blades of the heels of the inferior series more acute. Molars seven, the first one-rooted. Last molar with a cutting heel like the others, and with the penultimate, with a rudimental anterior inner cusp. All the molars with an anterior basal tubercle except the first, second and third. No basal cingula. Principal cusp elevated and compressed, as in the premolars of *Oxyæna*. Enamel minutely rugose. Mandibular rami and inferior canine teeth compressed, the angle of the latter not inflected. Length of inferior molar series M. .078 ; do. of premolar series .046 ; fourth premolar, length of base .010 ; elevation of cusp .008 ; second true molar, length .012, elevation .010 ; width of heel .005 ; depth of ramus at .020 ; diameter of base of crown of canine, vertical .009.

Periptychus carinidens, gen. et. sp. nov. Creodontium. *Char. Gen.* No distinct sectorial teeth, the first and second true inferior molars similar. They support a principal median cusp, a broad heel and a prominent anterior cingulum. The heel is more or less divided into tubercles ; the anterior cingulum is on the inner side, and represents the anterior cusp of a sectorial tooth. On the inner side of the principal cusp a cingulum rises, forming a flat internal tubercle. Last molar not smaller than the others ; premolars unknown.

This genus belongs to the *Amblyctonidæ* with *Amblyctonus* and *Palæonyctis*. It differs from both in the rudimental character of the anterior cusp, and from the former, in the presence of the internal tubercle. In *Mesonyx* the heel has a median cutting edge. *Char. Specif.* Parts of both mandibular rami and the shaft of a humerus represent this species. They indicate an animal of the size of the red fox, but much more robust. The mandibular ramus is rather shallow and thick, and the molars are not large. The heel of the penultimate supports three tubercles, of which the external is the largest. The anterior cingulum supports a small cusp, and then rises to the internal tubercle, which is compressed. The sides of all the cusps are marked with distinct, well separated, vertical ridges. Each extremity of the internal cusp is connected with the principal cusp by a ridge. The first true molar has fewer cusps. Those of the heel are scarcely distinct, and form a border which rises prominently into the flat internal tubercle, which forms a narrow longitudinal blade. The anterior cingulum has no cusp and does not rise into the inner tubercle. The principal cusp has a strong entering groove next the inner tubercle. Length of crown first molar .0115 ; width of do. .006 ; elevation of do. .006. Length of second molar .011 ; width of do. .007 ; elevation of do. .0065. Depth of ramus at do. .020. The species is a good deal smaller than the *Amblyctonus sinosus*.

Triisodon quivirensis, gen. et sp. nov. *Char. gen.* Derived from the lower jaw. Probably only three premolars. True molars alike, consisting of three anterior cusps and a heel. The cusps are relatively small and the heel large. Of the former the internal is much smaller than the external, and the anterior is rudimental, being merely a projection of the cingulum. The cutting edges of the large external cusp are obtuse. The heel is basin-shaped, and its posterior border is divided into tubercles, of which the external is a large cusp. The fourth premolar has no anterior inner tubercle, so that the anterior part of the crown consists of a compressed cutting cusp. The heel has two well-developed posterior cusps. The third premolar has a similar principal trenchant cusp, but a smaller heel. Canines large.

This genus differs from *Herpetotherium* and *Ictops* in the simplicity of its fourth inferior premolar, and from *Stypolophus* and *Deltatherium* in the rudimental character of the accessory anterior cusps of the true molars, as well as in the three premolars. The rudimental anterior cusp of the true molars, with the three similar true molars, separates it from *Pulæonyctis*, and the presence of a conic inner cusp of the same indicates it as different from *Amblyctonus* and *Periptychus*. It is not possible to state whether *Triisodon* must be placed in the *Amblyctonidæ* or not, on account of the absence of the superior molar teeth.

This specimen of the type species of this genus is instructive as showing the succession of premolar teeth. Both the third and fourth premolars have temporary predecessors. The predecessor of the fourth premolar differs much from it in form, and is essentially identical in all respects with the true permanent molars. The crown of the predecessor of the third premolar is wanting, the roots only remaining in the jaw.

The permanent third premolar was protruded before the permanent fourth. Which temporary tooth of *Triisodon* is homologous with the single one of the *Marsupialia* pointed out by Professor Flower?* As the additional permanent teeth of the placental *Mammalia* must have appeared later in time than the one already found in the implacentals, they must be those later protruded; hence the fourth tooth in the jaw of *Triisodon* must be regarded as homologous with the fourth premolar of a placental, which is the last of that series to appear. If this be true, the tooth which follows the shed tooth of the Marsupials is not the fourth premolar, as supposed by Professor Flower, but the third premolar. This view is confirmed by the fact that the milk tooth displaced by the fourth tooth in *Triisodon* resembles in all respects the true molars, just as the permanent tooth occupying the same position does in *Didelphys* and some extinct eocene genera. This goes to show that this tooth, permanent in marsupials, is temporary in placentals, and that, in spite of its form in the former group, it is the fourth premolar, and not the first true molar, as supposed by Professor Flower. Thus the posterior milk-molar of diphyodonts is a permanent tooth in the *Marsupialia*.

* Transactions of the Royal Society, 1867, p. 631.

This observation confirms my conclusion that the *Credonta* form a group intermediate between the *Marsupialia* and *Carnivora*. I may add that in *Trĭisodon* the inferior border of the lower jaw is not inflected posteriorly.

Char. specif.—Size about that of the wolf. Inferior canine directed upwards, its section nĕarly elliptic; a faint posterior, no anterior cutting edge. Fourth premolar rather large, with an anterior basal cingulum which is angulate upwards, and is not continued on the inner side of the crown. Cusps of the heel each sending a ridge forwards, the internal lower, obtuse and descending to base of inner side of large cusp; the external larger, with an acute anterior cutting edge continuous with the cutting edge of the large cusp. True molars with an external, but no internal basal cingulum. Border of heel with one large and three smaller tubercles, the former with, the latter without, anterior cutting edge. Enamel of all the teeth nearly smooth. All the cusps are rather obtuse. *Measurements.*—Length of inferior molar series: M. .080; long diameter of base of canine .013; length of true molar series .044; length of base of Prem. IV. .016; elevation of crown of do. .014; length of base of M. II. .016; width of do. in front .011; elevation of do., .014. The measurements of the jaw are not given, as the animal is not adult, the last molar not being yet protruded.

From the lowest Eocene beds of New Mexico.

Deltatherium fundaminis, gen. et sp. nov. *Char. Gen.* Fam. *Leptictidæ*, agreeing with *Ictops* and *Mesodectes* in possessing an internal tubercle of the third superior premolar, but differing from both in having but one external cusp of the fourth superior premolar. *Char. Specif.* Represented by the dentition of both maxillary bones minus the canines. The second premolar is convex on the inner face. The base of the third is a nearly equilateral triangle. The bases of the true molars are triangles, with the bases external. The internal angle supports an acute cusp, and has a posterior basal cingulum, which is very strong in the last three molars. The two external cusps of the first and second molars are situated well within the base, which is folded into a strong cingulum. This cingulum develops strong anterior and posterior angles. This is the largest species of the family yet discovered. Extent of series of last six molars, M. .045; of true molars .026; diameters of fourth premolar, anteroposterior .0074; transverse .0076; do. of second true molar, anteroposterior .0087; transverse .0100. This species was a fourth larger than the common opossum, and very much resembles it in dental characters.

Conoryctes comma, gen. et sp. nov. *Char. Gen.* Allied to *Mesonyx*. Inferior canines not rodent-like, with conic crowns. Molars 3—3, the first one-rooted, the second two-rooted, the third with an anterior conic cusp and a posterior grinding heel. True molars consisting of two lobes, of subcylindric section, separated by deep vertical grooves. Enamel developed on internal and external faces of crowns. *Char. Specif.* Founded on a mandibular ramus which lacks the last molar, and has the crowns of the others worn. The external faces of the molars are much more ex-

posed than the internal, and are somewhat contracted inwards. In the unworn crown there is a distinct anterior inner cusp, which is soon confounded on attrition. The heel of the last premolar has a crescentic section, the internal horn the narrower. The anterior lobe is a robust cone. The base of the second and third premolar is oblique to the axis of the ramus outwards and forwards. It is possible that there is a minute first premolar filling the short space between the second and the canine. No cingula; enamel obscurely plicate, ramus robust. Length of molars minus the last .0465; length of base of first true molar .010; width of do. .009; elevation of crown do. .0055; length of base of fourth premolar .011; width of do. .008; elevation of crown of do. .0065. Anteroposterior diameter of base of crown of canine .010. Depth of ramus at first true molar .023; width of do. at do. .013. This genus differs from *Esthonyx* in the form of the fourth premolar. In the latter the anterior lobe is compressed and trenchant. The species is larger than any of that genus, and nearly equal to the *Ectoganus gliriformis*.

Catathlæus rhabdodon, gen. et sp. nov. *Char. Gen.* With this genus I commence descriptions of several genera with bunodont dentition, which has some resemblance to that of some of the hogs. The one above named, with *Mioclænus*, remind one of *Tetraconodon* Falc. and Lydd., in the enlarged proportions of their premolar teeth. I compare the genera as follows, introducing a probably perissodactyle form (*Protogonia*) for comparison:

I. Third and fourth superior premolars one or two lobed externally, and with internal lobes.

a. Superior premolars with two external lobes; inferior fourth with two median cusps.

Intermediate tubercles; premolars not enlarged.....*Phenacodus.*

aa. Superior premolars enlarged, generally with one external cusp.

β. A posterior internal cusp of superior molars;

Intermediate tubercles present; last inferior premolar with inner cusp; *Catathlæus.*

Intermediate tubercles wanting, replaced by branches of an internal V; no cusp on inner side of last inferior premolar.....*Anisonchus.*

Intermediate tubercle present, connected with anterior inner by ridges; inferior molars with Vs.....*Protogonia.*

ββ. No posterior inner cusp of superior molars.

Intermediate tubercles present; no inner lobe of last inferior premolar *Mioclænus.*

II. Superior premolars 1, 2 and 3 without inner lobe; third with three external lobes (Pictet).

Premolars compressed.....*Dichobune.*

In the genus *Catathlæus* the development of the premolars is remarkable while the true molars are relatively small. The last three superior premolars have an elevated internal crescentic cingulum homologous with

the inner lobe of the fourth superior premolar of the ruminants. The general character of the true molars is that of *Phenacodus*. Parts of two or three individuals of this species have come into my possession, one of which includes nearly all of the molar dentition of both jaws. The external cusp of the superior premolars is compressed conic, and the internal cingulum extends to its *anterior* base in the second, third, and fourth. The crown of the last true molar is about as long as wide, while that of the first is wider than long. Each supports seven cusps; two subconic external, and one large median internal, which is connected by ridges with a small anterior and posterior median. Then there are a small anterior and posterior internal, making three internal. The internal crest is distinct from the principal cusp in the inferior premolars III and IV, but unites with it in the II; it supports on the IV an anterior, a median and a posterior cusp, the latter forming part of the rather narrow heel. The true molars I and II have seven tubercles, the four principal ones, and three smaller, one anterior, one posterior, and one median. On the third the posterior forms a large heel. All of the molars, but especially the premolars, have the enamel thrown into sharp vertical parallel folds, in a manner I have not seen in any other mammal. Length of six superior molars .067; length of three true molars .029; length of base of third premolar .012; width of do. .012; width of base of first true molar .010; do. of third true molar .009; length of do. .010. Length base fourth inferior premolar .012; width do. .010; length of third true molar .0115; width of do. .009. The teeth indicate an animal of the size of the peccary.

Anisonchus sectorius, gen. et sp. nov. *Char Gen.* This is derived from the superior P-m. IV and M. I and II, and from all the inferior molars of three individuals. The superior teeth are accompanied by a ramus mandibuli, which contains alveoli of all the inferior molars, and the crowns of the P-m. IV and M. II. The leading characters have been given above. The inner posterior lobe is more prominent in this genus than in any of the others, and has a V-shaped apex. It projects further inwards than the anterior inner lobe. It is represented by a mere tubercle of the cingulum in *Mioclænus*. In the lower jaw the last premolar is quite simple, consisting of a principal cusp, and a non-cutting heel. The second true molar has intermediate anterior and posterior cusps. The genus differs from *Pantolestes* in the more numerous tubercles of the molars, and in the fact that the anterior inner tubercle of the true molars is not double. It may, however, be allied to that genus.

Char. Specif. The fourth superior premolar covers a larger base than either of the true molars. The external cusp has a base extended antero-posteriorly, but the apex is conical, and there are no basal tubercles. The inner cusp has a crescentic base as in *Catathlæus*, but the apex is narrowed and compressed conic. The external tubercles of the true molars are subconic, and do not develop any external ridges. They are connected by the crescentic slightly angular crest, whose apex forms the inner ante-

rior boundary of the crown. This crest is not divided into parts homologous with the intermediate tubercles. The crowns of the M. I and II are surrounded by a basal cingulum, which in the M. I develops a tubercle at the anterior external angle. No internal or external cingulum on P-m. IV. Enamel nearly smooth.

The ramus of the mandible is rather slender anteriorly. The P-m. IV is robust, and the cusp is behind the middle of the base of the crown. The heel is short and narrow, and has a raised border, connected with the base of the main cusp. The cusps of the second true molar are elevated and conic, the anterior external the highest, the others subequal. The base of the posterior pair is a little narrower than that of the anterior pair. There is no central tubercle as in *Catathlæus rhabdodon*, and no basal cingulum on either tooth.

Measurements.		M.
Length of three superior molars		.0160
Diameters superior P-m. IV	anteroposterior	.0055
	transverse	.0070
Diameters superior M. I	anteroposterior	.0052
	transverse	.0060
Length of inferior molar series		.0610
" " " true molar series		.0160
Diameters inferior P-m. IV	anteroposterior	.0060
	transverse	.0040
Diameters inferior M. II	anteroposterior	.0050
	transverse	.0040
Depth ramus at M. II		.0090

A number of minor points will distinguish this species from those included among the *Mesodonta*, and especially those of *Pantolestes*, which it most resembles. The molar teeth are narrower behind, and the fourth premolar is larger. It is *Mioclænus sectorius*, American Naturalist, October, 1881, p. 831.

Mioclænus turgidus, gen. et sp. nov. This genus differs from *Catathlæus* in the structure of the inferior premolars, which are without internal crest or cusp. The inner lobe of the superior premolars is less developed than that genus. In the present species the characters of *Mioclænus* are best seen in the subconical tubercles of the premolars, particularly that of the heel of the fourth inferior premolar. In the other three species this heel is more of a crest and is connected with the principal cusp by a low ridge. The four species may be characterized as follows :

a. Cusps of last premolars conical in both jaws.

Size medium. Last lower molar disproportionately small ; cusps low ; two anterior inner distinct ; true molars, .018 ..... *M. turgidus.*

aa. Fourth superior premolar with flattened external and conic internal cusp ; inferior unknown.

Size medium; fourth upper premolor equilateral; all cusps acute; true molars .0165.....*M. subtrigonus.*

aaa. Cusps of last premolars compressed in lower jaw.

Least. Second and third lower true molars subequal; cusps, especially the internal, elevated; anterior inner confluent into an edge; true molars, .013.....*M. angustus.*

Largest; cusps of inferior molars obtuse; P-m. III .008, its heel short and small.....*M. mandibularis.*

Medium; last inferior molar larger than penultimate; true molars, .014; P-m. III .006.....*Anisonchus sectorius.*

Of *M. turgidus* there are two specimens; and of *M. subtrigonus, M. angustus* and *M. mandibularis* one each.

In the *M. turgidus* there are no cingula on the fourth premolar. It is wider than long, and the external face is a little flattened. The tubercles are conic; the external has a small one at the anterior base, and a rudiment at the posterior base, and there is a low one on the posterior side at the middle. The second true molar is wider than the first. The tubercles are all round in section. Besides those already mentioned, there is a rudiment of a posterior inner on the first, which is represented by a cingulum on the second. The latter has basal cingula all around except on the inner side; the same are visible on the first true molar in a rudimental condition. Enamel nearly smooth.

The inferior molars are of robust proportions. Their sizes are, commencing with the largest: P-m. IV; M. II; M. I; M. III. The last molar is only half as large as the penultimate. It has two anterior and an external lateral tubercles, and a heel. On the penultimate molar, there are two anterior tubercles with a trace of anterior inner; also a broad flat heel, with a low tubercle on the external side. The constitution of the first true molar is identical. The fourth premolar has a rudimental heel consisting of a low tubercle only. The principal cusp is conic and is over the middle of the transverse diameter, and a little behind the middle of the anteroposterior diameter. No cingula. Enamel nearly smooth.

Measurements.		M.
Maxillary bone.		
Length of base of P-m. IV, M. I and M. II		.0175
Diameters base P-m. IV	anteroposterior	.0055
	transverse	.0065
Diameters base M. I	anteroposterior	.0060
	transverse	.0070
Diameters base M. II	anteroposterior	.0060
	transverse	.0095
Mandible.		
Length of bases of last four molars		.0250
Diameters P-m. IV	anteroposterior	.0070
	transverse	.0055

Measurements.		M.
Diameters M. I	anteroposterior	.0060
	transverse	.0060
Diameters M. III	anteroposterior	.0055
	transverse	.0043
Depth of ramus at M. I		.0115
Thickness " " "		.0085

Mioclænus subtrigonus, sp. nov. Represented by a portion of a cranium anterior to the orbits and lacking the extremity of the muzzle, distorted by pressure. It exhibits nearly all of the molar teeth. The species differs from *M. turgidus* in the greater acuteness of all its cusps, and in the equilateral form of the fourth premolar. It is too large to belong to the *M. angustus*, which is represented by a mandible only ; and too small to be the *M. mandibularis*, whose maxillary dentition is unknown.

The inner borders of the molar teeth are shorter than the outer, especially in the last two molars. The last true molar is smaller than either of the others. The cusps are all subconical, but the internal is connected with the intermediate by ridges, which give it a triangular section. The latter form a V, homologous with that in *Anisonchus*, but not so distinct, and the intermediate tubercles are not lost in its branches as in that genus. The posterior inner lobe of that and other genera, is represented by a thickening of the cingulum. This cingulum extends entirely round the P-m. IV and M. I, and M. II ; the M. III is injured. The sides of the base of the P-m. IV are slightly concave. The enamel of all the molars is wrinkled.

Measurements.		M.
Length of bases of last five molars		.0285
Diameters of base of P-m. IV	anteroposterior	.0060
	transverse	.0050
Diameters of base of M. I	anteroposterior	.0060
	transverse	.0060
Diameters base of M. II	anteroposterior	.0060
	transverse	.0075
Diameters base of M. III	anteroposterior	.0040
	transverse	.0060

Mioclænus angustus Cope, American Naturalist, 1881, October (September 22d), p. 831. The least species of the genus, with the teeth about the size of *Hyopsodus paulus* Leidy, but with more robust jaw. The molar teeth diminish in size regularly posteriorly from the P-m. IV. They all have three subequal posterior cusps which are less elevated than the anterior ones. The median is enlarged into a heel on the last tooth. The anterior are opposite, and the external is larger than the internal. There is no anterior internal. The external wears into an anteroposterior narrow grinding surface, which looks like a combination with an anterior median. The latter is, however, not separate on the least worn molars. The

anterior outer cusp increases in size anteriorly, and is the large cusp of the P-m. IV. It sends a branch backwards on the inner side of the crown which forms the edge of the narrow concave heel. There are no cingula except a short one on the anterior corners of the base of the crown of the P-m. IV. Enamel obscurely wrinkled.

Measurements.		M.
Length of posterior four molars		.0180
Diameters of P-m. IV	anteroposterior	.0050
	transverse	.0035
Diameters of M. I	anteroposterior	.0050
	transverse	.0035
Diameters of M. II	anteroposterior	.0040
	transverse	.0032
Diameters of M. III	anteroposterior	.0045
	transverse	.0030
Depth ramus at M. I		.0110
Thickness " " "		.0060

PHENACODUS PUERCENSIS, sp. nov. Three individuals. Last superior molar smallest; first and second true molars with six tubercles, two external, two median and two internal. A strong basal cingulum except on inner side. Inferior true molars besides the usual five tubercles, furnished with an anterior ledge with a tubercle at its interior extremity. A weak external basal cingulum. A little larger than the *P. vortmani*. Length of superior true molars M. .021; length of base of crown of M. III .006; do. of M. I .008; width of do. .008; length of base of crown of inferior M. III .0085; width of do. in front .006; depth of ramus at M. I .019.

PHENACODUS ZUNIENSIS, sp. nov. The least species of the genus, represented by the mandibles of two individuals. The first and second true molars are narrowed in front, and there is no distinct anterior ledge, only a minute anterior inner tubercle. The external cingulum is more distinct and the enamel is wrinkled. The fourth premolar has a short base and the inner cusp is much smaller than the principal one; it has a wide heel and an anterior basal tubercle. Length of true molars, M. .018; of last true molar .006; of base of first true molar .006; width of do. .004; depth of ramus at do. .011.

PROTOGONIA SUBQUADRATA, gen. et sp. nov. Fourth superior premolar with one external and one internal lobe. True molars with two external, two internal, and two intermediate lobes, both the latter connected with the anterior internal by a ridge. Supposed inferior true molars with two Vs with weak anterior branches; last true molar with heel.

This genus will enter the *Chalicotheriidæ* of my system of *Perissodactyla*,* if the feet are found to possess the requisite characters. It is allied, apparently, also to *Hyracotherium*, but differs in the Vs of the infe-

*See Proceedings Amer. Philosoph. Society, 1881, p. 377-8.

rior molars, if they are properly identified; and in the superior molars. The anterior transverse crest of that genus is represented in *Protogonia*, but not the posterior. This is replaced by a low ridge running across the course it pursues in *Hyracotherium*. The posterior median tubercle is also not found in the latter genus. *Protogonia* differs from *Limnohyus* in the subconic character of the external lobes of the superior molars. If the tubercles, excepting the posterior inner, should be converted into crescents, the genus *Meniscotherium* would be produced.

Char. Specif. Probably two specimens; one supporting three superior molars; the other including damaged superior molars and the last two inferior molars. The animal was about the size of the red fox. The external cusp of the fourth superior premolar is flattened externally, and has a small lobe on its posterior edge. The inner tubercle is conic and is separated by a tubercle from the anterior base of the external. True molars without external ridges. The external cusps of the true molars are lenticular in section. The posterior inner cusp is in nearly the same antero-posterior line with the anterior, its section about equaling that of the intermediate cusps. The first and second molars have an external, an anterior and posterior, but no internal, basal cingula. The enamel is somewhat wrinkled where not worn.

The heel of the last inferior true molar is elevated, and its worn surface forms the extended posterior branch of the posterior V. The posterior edge of the penultimate molar is elevated and curved forwards on the inner side of the crown. The anterior cusp forming the angle of the V of this tooth, is higher than the posterior angular cusp, but the anterior limb descends rapidly as in *Coryphodon*. A weak antero-external, and postero-external cingula. Enamel wrinkled where not worn.

Measurements.		M.
No. 1.		
Length of bases of three superior molars		.025
Diameters of superior P-m. IV	anteroposterior	.0066
	transverse	.0086
Diameters of superior M. I	anteroposterior	.0085
	transverse	.011
Diameters superior M. II	anteroposterior	.009
	transverse	.011
No. 2.		
Length of bases of last two inferior molars		.0225
Diameters of last inferior molar	anteroposterior	.0114
	transverse	.0066
Diameters of inferior M. II	anteroposterior	.0112
	transverse	.0080
Depth of ramus at M. II		.0240
Thickness " " "		.0110

MENISCOTHERIUM TERRÆRUBRÆ, sp. nov. My specimens of this species embrace the dentition of several individuals.

The dimensions of the superior molars increase to the penultimate, while the external and posterior sides of the last molar are contracted, reducing its size. The external faces of the external Vs of the true molars are considerably impressed; those of the premolars are nearly flat.

The second premolar is two-rooted, and has a compressed crown, without either heel or cingulum, except a thickening of the posterior base. The base of the crown is triangular. The external plate of the third premolar is simple, and is connected with the internal cusp by a cingulum on the posterior base of the crown. The crown is transverse, and the inner tubercle rather small. The fourth premolar is much larger than the third. Its external plate is divided into two apices, which are not impressed. Their external faces are separated by a faint ridge, and are divided medially by a faint ridge. The anterior external angle is rather prominent. The anterior and a posterior cingulum extend to and round the inner base of the interior tubercle. Within the anterior external apex, is a well developed intermediate crest parallel to it; and there is a corresponding crest within the posterior external apex. This one turns inwards at its posterior extremity, which is on the posterior cingulum.

The anterior angle or horn of each external crescent of the true molars is very prominent. They are sections of short vertical ridges, which unite near the base of the crown, giving abruptness to the impression of the external surface of the anterior lobe. The middle of each face has a faint median ridge. The two molars have an anterior basal cingulum, but no posterior or internal, excepting a trace between the bases of the internal lobes. The anterior intermediate crescent is quite parallel with the external; the anterior internal tubercle has a slightly V-shaped section. The posterior inner tubercle is quite confluent with an oblique intermediate crest, as in *M. chamense*. In the last true molar, as there is only one internal tubercle, this crest is short, terminating at the posterior border. The last true molar is like the last premolar, except in its two impressed external crescents.

A fragment of the right branch of the lower jaw supports two molars, and the alveoli of two others, all of which have two roots. These teeth are the four premolars, although the last one has the form of the first true molar. Should my surmise be correct, then the third premolar has nearly the same form and structure as the fourth. The anterior horn of its anterior V is not produced quite so far inwards as in the fourth tooth. At the point of junction of the adjacent horns of the Vs there is a slight antero-posterior extension, forming a median buttress of the inner side of the crown as in *Anchitherium*. The posterior horn of the posterior V is also incurved, as in that genus. The angles of the Vs of the inferior molars are rounded.

The surfaces of the enamel of the teeth of both jaws is smooth.

Measurements.	M.
Length of superior molars, less P-m. I	.046
" of true molar series	.028
" of base of P-m. II	.005

Measurements.		M.
Diameters of base P-m. III	anteroposterior	.006
	transverse	.007
" of base P-m. IV	anteroposterior	.008
	transverse	.010
" of base of M. II	anteroposterior	.011
	transverse	.013
" inferior P-m. III (or IV)	vertical	.005
	anteroposterior	.007
	transverse	.005
Depth of ramus at same tooth		.012
Thickness ramus at succeeding tooth		.009

The *Meniscotherium terrærubræ* differs from the *M. chamense* in two features. The first is its superior size. The second is the flattened form of the external faces of the true molars and the absence of the convexity of the external bases of the crown.

My specimen of this species is from the red Eocene bed in Northwestern New Mexico, from the true Wasatch horizon, or higher than that which produced the other species here described. It was found by my assistant, D. Baldwin.

Remarks.

As stated in my report to Lieut. Wheeler in 1877, no vertebrate remains had been found in the Puerco beds, which underlie the Wasatch in New Mexico, up to that time. It was therefore uncertain whether they form the top of the Cretaceous or the bottom of the Tertiary series. I have recently obtained evidence of the existence of *Champsosaurus* in them, so that their position might be supposed to be in the Postcretaceous system.

It is however quite possible that the species of Mammalia described in this paper were derived from the Puerco Formation. Their horizon is below the Wasatch, and they represent a different fauna from that of those beds.

Attention has already been directed to this fauna in the pages of the *American Naturalist.** I have recorded the presence of the Creodont genera, *Periptychus*, *Triïsodon* and *Deltatherium*, and of the saurian *Champsosaurus*. I have now added the genera *Hyracotherium* and *Meniscotherium*, and a number of new forms of considerable interest. These are the Creodont *Mesonyx*, a new genus allied to *Esthonyx*, and a series of genera and species with a suilline type of dentition, but whose affinities are by no means certain. This point cannot be determined until the characters of the feet are known.

The facies of this fauna differs in several points from that of the Wasatch. *Coryphodon* has not yet been discovered in it, and the flesh-eaters are very primitive. The suilloid genera are characteristic.

*April, August and October, 1881.

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Prof. Chapman

PALÆONTOLOGICAL BULLETIN, No. 34.

CONTRIBUTIONS

TO THE

HISTORY OF THE VERTEBRATA

OF THE

LOWER EOCENE OF WYOMING AND NEW MEXICO,

MADE DURING 1881.

By E. D. COPE.

(*Extr. Am. Phil. Soc.*)

(Read before the Amer. Philosophical Society, Dec. 16, 1881.)

FOR SALE BY A. E. FOOTE,

1223 BELMONT AVENUE,

PHILADELPHIA.

Contributions to the History of the Vertebrata of the Lower Eocene of Wyoming and New Mexico, made during 1881. By E. D. Cope.

(Read before the American Philosophical Society, Dec. 16, 1881.)

I. The Fauna of the Wasatch Beds of the Basin of the Big Horn River.

The basin of the Big-Horn river contains the most northern area of the deposits of the Wasatch or Suessonian epoch known. In order to ascertain whether the fauna it contains differs in any way from that I discovered in the corresponding beds of New Mexico in 1874, I sent, during the past season, an expedition, under the direction of J. L. Wortman, already known from his successful exploration of the Wind River basin in 1880. The present paper gives a review of the results of the season's work, prefaced by an account of the geology furnished by Mr. Wortman. The species herein described are being engraved for the fourth volume of Dr. Hayden's report of the United States Geological Survey of the Territories, now passing through the press.

1. *The Geology of the Big-Horn Basin, by Jacob L. Wortman.*

As early as 1859 Dr. Hayden described in detail the Tertiary sediment occupying the upper drainage basin of the Big-Horn river, which he determined as belonging to the lower Eocene formation, and applied the name Wind River group, from its being exposed along the Wind river, a name given to the upper portion of the Big-Horn. From an extensive collection of vertebrate fossils made by the writer at this horizon, during the summer of last year, Prof. E. D. Cope, for whom the collection was made, has, in a bulletin, U. S. Geol. Surv. Terrs., F. V. Hayden, Vol. vi, No. 1, 1881, confirmed this determination, and discussed at length the faunal relations they bear both to the Bridger and Wasatch beds respectively. The conclusions reached are, that this series is intermediate to a certain degree, containing genera hitherto regarded as peculiar to each. This upper basin covers quite an extensive area, and is bounded upon every side by lofty mountains. The Owl Creek mountains, which afforded a barrier to the waters of this Eocene lake on the north, has subsequently been cleft by the Big-Horn, leaving a deep and rough cañon, through which it now flows in its course north to the Yellowstone. After passing the Owl Creek mountains it emerges into a second or lower basin, commonly called the Big-Horn basin proper. This one covers a much larger area than the upper, and like it is walled in by mountain ranges, and filled with a mass of sedimentary rock which is also referable to the lower Eocene series.

During the summer of the present year the writer has been engaged in further exploration of this interesting region, which resulted in the collection of a large number of extinct vertebrates, obtained exclusively from the lower Eocene horizon of the Big-Horn, and which have all been sub-

mitted to Prof. Cope, at whose instance the party was organized and equipped.

Dr. Hayden has made the observation that upon the eastern slope of the Wind River mountains all the corresponding strata are visible from the Silurian to the Cretaceous; this is also true of the northern slope of the Owl Creek mountains, while the southern side does not exhibit such continuity of structure. Upon entering the basin from the south, the older formations are seen to extend towards its centre for a distance of ten miles, inclining at an angle of 30° to the north, while the level of the Tertiary has been little or not at all disturbed since its deposition. That this basin contained a separate and isolated body of water, limited by its present boundaries, which were outlined about the beginning of the Wasatch epoch, there is every reason to believe. A section made by the Big-Horn at the southern extremity shows the Tertiary to rest unconformably upon a thick mass of buff colored sandstone, rather coarse in texture, somewhat laminated, and towards the bottom interspersed with thin layers of impure lignite varying from six inches to one foot in thickness. This sandstone most probably belongs to the Laramie series, but in the absence of fossils the determination is by no means satisfactory.

The Eocene sediment covers a large part of the basin, and cannot be less than 4000 feet in vertical depth. This mass, once continuous over a large area, has since been carved and weathered into many fantastic and remarkable forms, presenting at once a bold and striking appearance, a characteristic feature of the western Tertiary bad lands.

Beginning at the southern limit at a point opposite the mouth of Meyers creek, on the east side of the river, a series of low bad land bluffs, facing to the west and gradually becoming higher as they proceed, describe a gentle curve to the north, terminating at the river's edge 30 miles below. The character of the country between the river and these bluffs is a barren sage brush plain, while back of the bluffs a high mesa occupies the country for many miles. On the west side, numerous rivers, creeks, and their tributaries, putting down from the Sierra Shoshone range, have excavated the mass in every direction, leaving bold escarpments, high bad land buttes, elevated tables, with innumerable gulches and ravines. Country of this character stretches far away to the northern limit, near the Big Horn gap, presenting that desolate and sombre appearance, so often met with in bad land regions,

Its composition may be described as consisting of various colored clays alternating with layers of brown and blue sandstone, although that evenness of stratification by which a single layer of either, in one part, could be identified in another, does not exist. Those exposures, for example, on the east side of the Big-Horn are highly arenaceous, the clay and sand existing in almost equal proportions, while in the exposures along the Grey Bull river, and in the vicinity of Coryphodon butte, the quantity of sand is greatly diminished, and is found in separate layers. The preponderance of the red clay is a marked feature, and has called forth the

remark from Dr. Hayden, relative to the sediment of the upper basin, "that they remind one of the Jura Trias red beds." This remark is forcibly illustrated by the character of the sediment found in the south-western part of the basin, near the head of Gooseberry creek, where the exposures consist largely of thick strata of the red clay, which gradually thin out to the north and east, blending with the pink, blue, and buff colors. In the northern part of the basin, and along Stinking river, the sediment consists almost exclusively of a pale yellow sandstone of a bluish tinge, from which few fossils were obtained.

The clays contain much lime in the form of small limestone nodules of a rusty brown appearance, in which the fossils are often found, having a thin and intensely hard layer of ferrous oxide investing them externally. In the red the fossils are always scarce and fragmentary, and when found are usually such parts as would, under the most favorable circumstances, be preserved. The blue seems to be the more productive, and to have offered better conditions for their preservation; but, owing to the fact that lime forms the petrifying base, and being less able to withstand the heavy pressure than many other materials, the fossils from both the red and the blue are, as a general rule, greatly distorted and crushed. This fragmentary occurrence of fossils in the fine-grained clay, I am inclined to believe, is due, not to a scattering of the bones by currents, but rather to imperfect and unfavorable conditions for their preservation. That entire skulls and skeletons were deposited, where now nothing but the teeth remain, I am well satisfied from the circumstance that both superior and inferior series are not unfrequently found in proper position without a trace of ramus or cranium. In the sandstones, however, the fossils are in a magnificent state of preservation, but their extreme scarcity in this material gives the collector many long and fruitless searches. Two skeletons which have proven of considerable interest were all of any consequence that were obtained from the sandstones.

The general stratigraphical appearance, as well as the scattered and fragmentary condition of the fossils, together with the community of a large number of genera, refer it to the Wasatch epoch, but a full discussion of this point belongs properly to the paleontologist. A thorough elucidation will be found in Prof. Cope's paper on the fossils.

The exploration of this region is most arduous and difficult. The great scarcity of water in these bad land wastes, makes it very inconvenient, and renders it necessary to carry a water supply a distance of often 20 miles or more. Even when water does exist it is so strong with alkali as to be scarcely fit for use. Many of the streams coming down from the mountains dry up as soon as the snow has melted from the low foot hills in early spring, leaving large tracts entirely destitute of water, which frequently abound in fossiliferous exposures, and which it is the object of the explorer to examine. The broken and mountainous character of the country forbids the use of wagons to such an extent that pack animals are indispensable.

The accompanying map is intended to illustrate the exact position, as well as the extent of country covered by the Wasatch sediment at this point. Its topography is taken from a map made by Capt. J. Russell, Third Cavalry, U. S. A. (and published by the War Department), during a reconnoissance of that region in the summer of 1880, and to whom, as well as Dr. W. H. Corbusier, Col. J. W. Mason, and other officers stationed at Fort Washakie, I wish to express my deep sense of obligation for their very kind and courteous treatment.

Map of the Big-Horn Basin, reduced from the Map of the U. S. War Department.

2. *Synopsis of the Fauna.*

PISCES.

Clastes sp. ; not abundant.

Pappichthys sp. Vertebræ ; not very common.

REPTILIA.

Crocodilus sp. Allied to the *C. chamensis* and *C. heterodon*, but not represented by sufficiently well preserved specimens to permit of determination. There are numerous molariform teeth in the posterior parts of jaws, and the crowns of the longer teeth are grooved. Not uncommon.

Emys sp. Rare; one specimen of 220 mm. in length, of the type of *E. wyomingensis*, but not sufficiently well preserved for determination.

As the Eocene forms of this order are of unusual interest, I give an analysis of the extinct genera of the Cryptodire division of tortoises which have been found in North America up to the present time.

In the check-list of the North American *Batrachia* and *Reptilia*,* I enumerated nine families of this division of the *Testudinata*, three of which are extinct. Subsequently another extinct family, the Baënidæ, was added. I now define all of these families.

I. Plastron not articulated to the carapace, but presenting to it more or less open digitations. *Dactylosterna.*

Phalanges of anterior limb without condyles, and covered by a common integument; eight pairs of costal bones ..... *Cheloniidæ.*

Phalanges of anterior limb without condyles; nine or more costal bones, *Propleuridæ.*

Phalanges of anterior limb with condyles; digits inclosed in distinct integuments; eight costal bones; sternal elements united by digitations and inclosing fontanelles; caudal vertebræ procoelous... *Trionychidæ.*

Phalanges of anterior limbs with condyles; digits distinct; eight costal bones; sternal elements united by suture and inclosing no fontanelles; caudal vertebræ opisthocoelous ..... *Chelydridæ.*

II. Plastron uniting with the costal bones of the carapace, by denticulate suture, and by ascending axillary and inguinal buttresses. (Feet ambulatory.) *Clidosterna.*

A. Intersternal bones present.

No intergular scuta ..... *Pleurosternidæ.*†

Intergular scuta; caudal vertebræ opisthocoelous ..... *Baënidæ.*

AA. No intersternal bones.

a. Intergular scuta.

A mesosternal bone ..... *Adocidæ.*

aa. No intergular scuta.

A mesosternal bone; three series of phalanges ..... *Emydidæ.*

No mesosternal bone; three series of phalanges ..... *Cinosternidæ.*

A mesosternal bone; two series of phalanges ..... *Testudinidæ.*

* Bulletin U. S. National Museum, No. 1, 1875. p. 16.

† There are two genera of this family, neither of them yet found in America; *Pleurosternum* Ow., with smooth shell, and *Helochelys* Myer, with sculptured shell.

III. Plastron uniting with the marginal bones of the carapace by straight contact only. (Feet ambulatory.) *Lysosterna.*

No intersternal bone nor intergular scutum ; a mesosternal bone and three series of phalanges..... *Cistudinidæ.*

The extinct species of the *Cryptodira* of this continent belong to eight of the above families. I give diagnoses of the genera to which they are referred. Names of existing genera are in Roman type.

CHELONIIDÆ.

Postabdominal bones distinct from each other.....Chelonia Brong.
Postabdominal bones united with each other by suture..*Puppigerus* Cope.

PROPLEURIDÆ Cope.*

Transactions of American Philosophical Society, xiv., 1870, p. 235.

Ten costal bones ; first two marginals united with carapace by suture ; shell smooth, flattened..... *Osteopygis* Cope.
Nine costal bones ; first two marginals united to carapace by suture ; shell sculptured (a high dorsal keel)..... .....*Peritresius* Cope.
Nine costal bones ; one marginal united with carapace by suture ; second by costal gomphosis ; shell not keeled nor sculptured .....
Propleura Cope.
? Nine costal bones ; first united with carapace by suture ; second without costal gomphosis ; shell not sculptured.....*Catapleura* Cope.
? Nine costal bones ; marginals all free ; shell not sculptured.....
Lytoloma Cope.

TRIONYCHIDÆ.

a. Surface of bones smooth.

Postabdominal suture digitate .....*Axestus* Cope.

aa. Surface of bones sculptured.

β. Sutures of plastron digitate.

A dermal flap protecting posterior legs below ; marginal bones.....
Emyda Gray.
A dermal flap ; no marginal bones.....Cyclanosteus Peters.
No dermal flap nor marginal bones ; muzzle much abbreviated.....
Chitra Gray.
No dermal flap nor marginal bones ; muzzle elongate....Trionyx Geoffr.

ββ. Suture for postabdominal coarsely serrate.

Postabdominal recurved in front.....*Plastomenus* Cope.

CHELYDRIDÆ.

a. Bridges of plastron wide ; ? caudal vertebræ.

One row of marginal scuta ; six pairs of scuta of the plastron.....
Idiochelys Myr.

* *Palæochelys novemcostatus* Geoffr., belongs to this family, but not *Palæochelys* Myr.

One row of marginal scuta ; scuta of plastron ? not distinct.....
Hydropelta * Myr.

aa. Bridges of plastron very narrow.

β. Carapace smooth, not sculptured.

Two rows of marginal scuta ; five pairs of scuta of the plastron.....
Macrochelys Gray.

One row of marginals ; five pairs on plastron.....Chelydra Schw.

One row of marginals ; four pairs of scuta on plastron....Claudius Cope.

ββ. Carapace sculptured.

One row of marginal scuta.....*Anostira* Leidy.

Baënidæ.

Cope, Annual Report U. S. Geol. Surv. Terrs., 1872 (1873), p. 621.

Supramarginal scuta (Rütimeyer) ; no interhumerals.....*Platychelys* Myr.

No supramarginals nor interhumeral scuta.....*Baëna* Leidy.

No supramarginals ; interhumeral scuta present .....*Polythorax* † Cope.

Adocidæ.

Cope, Proceedings American Philosophical Society, 1870, p. 559.

a. Vertebral bones and scuta normal.

One intergular scutum entirely separating the gulars.....*Adocus* Cope.

Either two intergulars, or the gulars meeting behind intergular.....
Amphiemys Cope.

aa. Vertebral bones wedge-shaped, widening upwards ; vertebral scuta not wider than the bones.

Elements of carpace early coössified.....*Homorhophus* Cope.

Emydidæ.

a. No scutal sutures.

Surface sculptured.....*Apholidemys* Pom.

aa. Scuta including intermarginals and two anals.

Lobes of sternum narrow.....Dermatemys Gray.

Lobes of sternum wide.....*Agomphus* Cope.

aaa. Scuta ; two anals, no intermarginals.

Surfaces of carapace sculptured ; plastron fixed.....*Compsemys* Leidy.

Surfaces of carapace smooth ; plastron fixed ; recent *Emydidæ* and the genus.....Emys Brong.‡

Posterior lobe of plastron movable ; surface smooth....*Ptychogaster* Pom.

Anterior and posterior lobes of plastron movable ; surface smooth.....
Dithyrosternum Pict. et Humb.

aaaa. Scuta ; one anal, no intermarginals.

Carapace smooth .....*Stylemys* Leidy.

* *Eurysternum* Wagn. (*Palæomedusa* et *Acichelys* Myr. (fide Rütimeyer) is nearly allied to *Hydropelta*.)

†Possibly one of the *Adocidæ ;* see Proceed. Acad. Phila., Oct., 1876.

‡ Gray has distinguished several good genera among existing species on cranial characters.

TESTUDINIDÆ.

a. Two anal scuta.

Ten abdominal scuta.....*Hadrianus* Cope.

aa. One anal scutum.

Lower jaw with two cutting edges.....Xerobates Agass.
Lower jaw with one cutting edge.....Testudo Linn.

RODENTIA.

PLESIARCTOMYS BUCCATUS Cope.

Two mandibular rami.

PLESIARCTOMYS DELICATIOR Leidy.

Mandibles of six individuals, some of them accompanied by bones of the skeleton.

BUNOTHERIA.

TÆNIODONTA.

Additional material gives the following results with regard to the affinities of this sub-order. There are three allied groups represented by the genera *Esthonyx*, *Tillotherium* and *Calamodon* of the American Eocenes, which are equally unlike each other. *Esthonyx*, as I long since showed, is related to the existing *Erinaceus;* very nearly indeed, if the dentition alone is considered. Its anterior incisor teeth are unusually developed, and have, as in *Erinaceus*, long roots. One pair at least in the lower jaw has enamel on the external face only, and enjoys a considerable period of growth. The genus *Tillotherium* is (fide Marsh) quite near to *Esthonyx*. Its molars and premolars are identical in character with those of that genus, the only important difference being found in the incisors. Here, one pair above, and one pair below, are faced with enamel in front only, and grow from persistent pulps as in the *Rodentia*. This character has been included by Marsh in those he ascribes to his "order" of *Tillodontia*, but as he includes *Esthonyx* in that order,* which does not possess the character, it is not very clear on what the supposed order reposes. The rodent character of the incisors is the only one that I know of which distinguishes *Tillotherium* from the *Insectivora*. I have on this account retained the *Tillodonta* as a sub-order, and referred *Esthonyx* to the *Insectivora*.

The *Tæniodonta* agree with the *Tillodonta* in the possession of a pair of inferior incisors of rodent character, but it adds several remarkable peculiarities. Chief among these is the character of the inferior canines. In the *Tillodonta* they are either wanting, as in *Erinaceus*, according to the Cuvierian diagnosis, or they are insignificant. In *Calamodon* they are of large size, and though not as long-rooted as the second incisors, grow from presistent pulps. They have two enamel faces, the anterior and the posterior, the former like the corresponding face of the rodent incisors.

* Report of U. S. G. Survey 40th Parallel, by Clarance King; Vol. i, p. 377.

The function of the adult crown is that of a grinding tooth. This character distinguishes *Calamodon* as a form as different from *Tillotherium*, as the latter is from *Esthonyx*. There are, however, other characters. The external incisors, wanting in *Tillotherium*, are here largely developed, and though not growing from persistent pulps have but one, an external band-like enamel face. Their function is also that of grinders.

The fact that the rodent teeth in the lower jaw are the second incisors, renders it probable that those of the *Tillodonta* hold the same position in the jaw. This is to be anticipated from the arrangement in *Esthonyx*, where the second inferior incisors are much larger than the first and third. The superior dentition of the *Tæniodonta* is yet unknown.

CALAMODON SIMPLEX Cope.

Report Vertebrate Foss., New Mexico, U. S. Geog. Surv. W. of 100th Mer. 1874, p. 5. Report of do. Capt. G. M. Wheeler, IV, ii, p. 166.

A nearly complete mandible of this species was found by Mr. Wortman, besides a series of unworn molar and canine teeth of a second individual, and fragments of some others. These furnish the correct dental formula as far as they go, as follows : I. 3 ; C. 1 ; M. 5. It appears that I correctly referred the long rodent teeth to the lower incisior series, but that the truncate two banded teeth so characteristic of the sub-order, are canines and not incisors, and that they belong to the lower as well as probably to the upper jaw.

The characters of the incisors are very peculiar. The first are small with short subcylindric crowns, and conic roots. The second incisors have been described ; as in *C. arcamænus* they have a horizontal shoulder posterior to the base of the cutting portion. The third incisors increase in diameter upwards, and have a triangular section. The largest side of the triangle is interior, and the shortest the posterior, and neither possess any enamel. The anterior or enamel faced side is slightly convex. The grinding face is transverse and is in the plane of the corresponding face of the canine. The long diameter of the crown of the canine is at right angles to the anterior face of the third incisor, and diagonal to the long axis of the mandibular ramus. This, with the peculiarities of the other incisors, gives an irregular appearance to the anterior dentition.

The five molars are very similar in character, and even those with unworn crowns do not present any distinction into premolars and true molars. The enamel covers the summit of the crown, but on wearing, it is soon reduced to a cylindrical sheath. Further wear brings the grinding surface to the anterior and posterior surfaces which are covered with cementum instead of enamel.

INSECTIVORA.

ESTHONYX BURMEISTERI Cope.

Report Vertebrate Foss., New Mexico, 1874, p. 7. Report U. S. G. G. Surv. W. of 100th Mer. G. M. Wheeler, IV, ii, p. 156, pl. XI, fig. 26.

Two fractured crania exhibit the entire dentition of this species, and give the generic characters satisfactorily. The dental formula is, I. $\frac{2}{3}$; C. $\frac{1}{1}$; P-m. $\frac{?3}{3}$; M. $\frac{3}{3}$. The first superior incisor is large, and the crown is somewhat spoon-shaped. The second incisor is as robust as the first, but the crown is shorter. The second premolar has one external and one internal lobe, in the third (fourth) premolar these lobes are much enlarged, and the tooth is transverse. The true molars have two external cusps, which are flattened, close together, and well within the margin of the base of the crown. There is one internal lobe and a strong posterior ledge, as in the opossums. Of the inferior incisors, the median is large and half gliriform, while the first and third are small. The inferior, like the superior canines, are large. The first and second (third) premolars have no internal lobes, but the second (third) has a heel. The fourth is more or less like the first true molar.

The specimens show that my original determinations of the incisors based on loose teeth were correct. They also show that this genus is not far removed from the more rodent-like genus *Anchippodus* of Leidy.

There are several species of the genus, which I define as follows:

I. Fourth inferior premolar like first true molar.

Larger; third superior premolar larger; fourth premolar with the external cusp bilobate..... *E. acutidens.*

Medium; third superior premolar smaller; fourth premolar with external cusp simple; superior incisors wide; large inferior narrower..... *E. burmeisteri.*

Medium; superior incisors narrow; large inferior wider.... *E. bisulcatus.*

II. Fourth inferior premolar with anterior V open and cutting.

Smallest; incisors unknown..... *E. acer.*

A species of the size of *E. acer* has been named *E. spatularius*, but I cannot place it in the above key, as the premolar and incisor teeth are unknown. The section II, approximates nearer the genus *Conoryctes* than sect. I.

Mesodonta.

Hyopsodus lemoinianus, sp. nov.

This Mesodont is distinguished from the known species of the genus by its superior size, and the fully developed heel of the inferior third molar. The anterior inner cusps of the inferior molars are absolutely simple, and the same teeth have a weak external and no internal cingulum. The cusps are elevated and the enamel smooth.

The species of this genus known to me by their mandibles are four, and these differ chiefly in size. Their characters are as follows:

Length of true molars M. .0165; last molar elongate..... *H. lemoinianus.*

Length of true molars M. .0140; last molar longer than second..... *H. paulus.*

Size as last; last molar shorter than second.....*H. miticulus.*
Length of true molars M. .0115; last molar elongate.....*H. vicarius.*

H. lemoinianus and *H. miticulus* have not been found out of the localities where they were discovered, while the other two species are distributed through most of the Eocene horizons, and have been found in many localities. Of the *H. lemoinianus* Mr. Wortman found nine more or less fragmentary mandibles.

Dedicated to my friend, Dr. Victor Lemoine of Reims, well-known for his brilliant discoveries in the vertebrate paleontology of the Lower Eocene beds near that city.

HYOPSODUS PAULUS Leidy.

Thirty-eight more or less broken mandibular rami.

HYOPSODUS VICARIUS Cope.

Eleven mandibular rami. A few specimens are intermediate between this species and the last in dimensions, the inferior true molars measuring M. .0120 and .0125 in length.

PANTOLESTES CHACENSIS Cope.

Four mandibular rami. This species has the fourth premolar more robust and less trenchant than in *P. secans*, and shorter than the last true molar. In *P. secans* it is longer than the last true molar.

PANTOLESTES METSIACUS sp. nov.

A small species of the size of the *P. longicaudus*, and distinguished by several peculiarities of dentition. The two cusps composing the anterior internal lobe of the molars are quite distinct but appressed. Each one is connected with the external anterior lobe by a transverse crest as is seen in *Esthonyx*, and these enclose between them a fossa. This fossa is closed internally by the appression of the anterior inner cusps. The fourth premolar is not so large as in *P. secans*, but resembles in proportions that of *P. chacensis*. It differs from that of *P. longicaudus* in its very short heel and its large anterior basal tubercle. The latter is double, consisting of two small cusps, one within and anterior to the other. The posterior heel is distinct on both sides of the ridge that marks the median line. The posterior external lobe is V-shaped, and the posterior inner is a small cone. Between the two is a minute median tubercle. The posterior tubercles are not so elevated as in the species of *Hyopsodus*. A weak external cingulum; enamel smooth.

Measurements.	M.
Length P-m. IV, with M. I, and II; (No. 1).....	.0140
" P-m. IV.....	.0048
" M. II.....	.0045

Measurements.	M.
Width M. II	.0040
Length M. III; (No. 2)	.0050
Width "	.0030
Depth ramus at P-m. IV; (No. 1)	.0060
" " M. III; (No. 2)	.0070

Portions of four mandibles preserved. No. 2 is a little smaller than No. 1, and No. 4 is a little larger than No. 1.

The species of *Pantolestes* may be distinguished as follows:

a. Fourth premolar trenchant everywhere, longer than second molar. Length of true molars M. .0150; second molar with but one anterior inner cusp.....*P. secans.*

aa. Fourth premolar with blunt heel, not longer than second molar. Length of true molars .0160; all with double cusps.....*P. chacensis.*
Length of true molars .0140; fourth premolar with minute anterior cusp, and long heel.....*P. longicaudus.*
Length of true molars .0130; fourth premolar with double anterior cusp, and short heel; molars with double cusps.....*P. metsiacus.*
Length of true molars .0105; fourth premolar small, .0035, without anterior cusps, and with two ridges on heel; true molars with double anterior inner cusps.....*P. nuptus.*

PANTOLESTES NUPTUS, sp. nov.

This is the last species of the genus, and is represented by a portion of a right mandibular ramus which supports three molars from the fourth to the sixth inclusive. Besides its small size, this species is distinguished by the relatively small dimensions of the fourth premolar, which is shorter than the first true molar instead of longer, as in all the other species. The well developed basin of its heel, which is bounded by a ridge on each side, distinguishes it at once also from *P. secans*, and is more distinct than in *P. chacensis;* from the latter and *P. metsiacus* the entire absence of anterior basal lobes separates it. The well developed pair of anterior inner tubercles of the true molars shows that it cannot be an abnormal *Hyopsodus vicarius*, with which it agrees in size. The first anterior tubercle is more widely separated from the second anterior than in any of the species of the genus, and is quite as in species of *Pelycodus*. It is smaller than the second anterior inner, which equals in size the anterior outer. The heel is wide, enclosing a basin, which is bounded externally by an angular ridge. Its posterior inner angle supports a cusp, which is separated by a deep notch from the anterior inner cusp. External to it on the posterior border of the crown is a small tubercle. No basal cingula.

Measurements.	M.
Length of three molars	.010
Diameters of M. i { anteroposterior	.004
Diameters of M. i { transverse	.003
Depth of ramus at P-m. IV	.007

Basin of the Big-Horn; J. L. Wortman.

Pelycodus angulatus Cope.

The species of this genus are, in the present state of our knowledge, best distinguished by their size.

Length of true molars on base.....M. .024 ; *P. pelvidens.**
" " " " .....M. .019 ; *P. jarrovii.*
" " " " .....M. .017; *P. tutus.*
" " " " .....M. .015 ; *P. frugivorus.*
" " " " .....M. .012 ; *P. angulatus.*

Remains of species of this genus are very common in the Wind River bad lands ; they were originally found in the Wasatch beds of New Mexico, and have not yet been announced from the Bridger formation.

The *P. angulatus*, heretofore only known from New Mexico, is represented in the Big-Horn collection by five mandibular rami, and a portion of a maxillary bone with teeth.

Pelycodus frugivorus Cope.

Two mandibles and seven separate rami represent this Mesodont.

Pelycodus tutus Cope.

Four rami display the typical length of the true molars, M. .017. Three are smaller, having the molars .016 in length, while one gives .018 for the same teeth. Other portions of the skeleton will be necessary to determine exactly the specific position of these specimens.

Prosimiæ.

Cynodontomys latidens, gen. et sp. nov.

Char. gen. Derived from mandibular rami. Dental formula I. ? 0 ; C. 1 ; P-m. 2 ; M. 3. The premolars are counted as two, on the supposition that the anterior one is two-rooted ; should it prove to be one-rooted, then the number will be three. The canines are very large and close to the symphysis, so that there do not appear to have been any incisors. The true molars have the frequently occuring three tubercles in front and a heel behind ; but the arrangement is peculiar in that the three tubercles are but little more elevated than the borders of the heel, and occupy a small part of the crown. The last molar is lost from both jaws, but the space for it is about as large as that occupied by the penultimate. The fourth premolar has but two anterior cusps, and these are more elevated than those of the true molars, and the heel is narrower. The mandibular rami are not coössified.

The dental characters of this genus resemble considerably those of *Anaptomorphus* and *Necrolemur*, but the large size of the inferior canine tooth distinguishes it from both. The double anterior cusps of the fourth premolar equally distinguish it from them.

Char. Specif. The inferior true molars are subquadrate in horizontal outline, somewhat narrowed anteriorly. The concave heel is the larger part of the crown ; it is only elevated into a low cusp at the posterior external angle. The anterior cusps are conic, and are in contact at the

* *Lipodectes pelvidens* Cope, Amer. Naturalist, Dec., 1881, p. 1019.

base. The external and posterior internal are of about the same size; the anterior inner is smaller and does not project so far inwards as the posterior. The fourth premolar has the posterior border of its heel serrate. The anterior cusps are elevated and moderately acute; the internal is a little less elevated than the external, and is separated from it by a deep notch. The alveoli for the anterior premolar are so close together, as to render it probable that they belong to but one tooth. They are placed somewhat obliquely to the long axis of the jaw. There is no diastema. The section of the base of the crown of the canine is a regular oval, the long diameter coinciding with the vertical diameter of the ramus.

The ramus is rather slender, but is shortened anteriorly. The boundaries of the masseteric fossa are well marked, the anterior ridge descending to below the middle line of the ramus. The mental foramen is large and is situated below the contact of the two premolars. The inferior edge of the ramus is rather thick.

Measurements.	M.
Length of dental series including canine	.0240
" premolars	.0062
" molars	.0114
Long diameter base canine	.0036
Diameters P-m. IV { anteroposterior	.0038
Diameters P-m. IV { transverse	.0026
" " M. II. { anteroposterior	.0042
" " M. II. { transverse	.0038
Depth of ramus at P-m. I	.0060
" " " M. III	.0068

ANAPTOMORPHUS HOMUNCULUS Cope, American Naturalist, 1882, Jan. (Dec. 30th, 1881), p. 73.

The genus *Anaptomorphus* was characterized by me in 1872,* from a mandibular ramus which exhibited the alveoli of all the teeth, three of them occupied by the teeth; viz.: the P-m. iv, and the M. i and M. ii. From the specimen the inferior dental formula was ascertained to be I. 2; C. 1; P-m. 2; M. 3. The Big-Horn collection contains a nearly entire cranium of what is probably a species of the same genus. From it the superior dentition, exclusive of the incisors, is determined to be: C. 1; P-m. 2; M. 3. The premaxillary bones are mostly broken off, but a part of the alveolus of the external incisor of one side remains.

The indications are that the external incisor was a small tooth, not exceeding the canine in size; and it was situated close to the latter. The canine is also small, and its simple crown is not more prominent than those of the premolars. The latter are separated from it by a very short diastema. The long diameter of their crowns is transverse to the long axis of the

* Proceedings American Philosophical Society, 1872, p. 554. Paleontological Bulletin, No. 8, p. 1, Oct. 12, 1872.

jaw ; and each one consists of a larger external, and smaller internal cusp. The true molars are also wider than long, and support two external and only one internal cusps.

The orbits are large and are entirely enclosed behind. The frontal bone does not send inwards to the alisphenoid a lamina to separate the orbit from the temporal fossa, as is seen in *Tarsius*. There is no sagittal crest, but the temporal ridges are distinct. The occipital region protrudes beyond the foramen magnum, or at least beyond the paroccipital process, which is preserved, the condyles being lost. The otic bulla is large, extending anteriorly to the glenoid cavity. The pterygoid fossa is large, the external pterygoid ala being well developed, and extending well upon the extero-anterior side of the bulla, as in *Tarsius*. As in that genus, the foramen ovale is situated on the external side of the bulla, just above the base of the external pterygoid ala. The carotid foramen, as I suppose it to be, is situated at the apex of the bulla. The lachrymal foramen is situated anterior to, and outside of the orbit as in *Lemuridæ* generally.

The cast of the anterior part of the left cerebral hemisphere is exposed. This projects as far anteriorly as the middle of the orbits, leaving but little room for the olfactory lobes. The relations of the latter as well as of other parts of the brain will be examined at a future time. The part exposed does not display fissures, and gentle undulations represent convolutions.

The characters of this genus now known, warrant us in thinking it one of the most interesting of Eocene Mammalia. Two special characters confirm the reference to the *Lemuridæ* which its physiognomy suggests. These are, the external position of the lachrymal foramen, and the unossified symphysis mandibuli. Among *Lemuridæ*, its dental formula agrees only with the *Indrisinæ*, which have, like *Anaptomorphus*, two premolars in each jaw. But no known *Lemuridæ* possess interior lobes and cusps of all the premolars, so that in this respect, as in the number of its teeth, this genus resembles the higher monkeys, the *Simiidæ* and *Hominidæ*,* more than any existing member of the family. Of these two groups the resemblance is to the *Hominidæ* in the small size of the canine teeth. It has, however, a number of resemblances to *Tarsius* which is perhaps its nearest ally among the lemurs, although that genus has three premolars. One of these points is the anterior extension of the otic bullæ, which is extensively overrun by the external pterygoid ala. A consequence of this arrangement is the external position of the foramen ovale, just as is seen in *Tarsius*. Another point is the probably inferior position of the foramen ovale. Though this part is broken away in the cranium of *Anaptomorphus homunculus*, the paroccipital process is preserved, and has the

* In an early description of *Anaptomorphus*, Proc. Amer. Philos. Soc., 1873, the types make me say "this genus * * might be referred decidedly to the *Lemuridæ*, were it not for the unossified symphysis." It is scarcely necessary to state that *Simiidæ* should be read in place of *Lemuridæ*.

position seen in *Tarsius*, as distinguished from the *Indrisinæ*, *Lemurinæ*, *Galaginæ*, etc. In this it also resembles the true *Quadrumana*.

When we remember that the lower *Quadrumana*, the *Hapalidæ* and the *Cebidæ*, have three premolar teeth, the resemblance to the higher members of that order is more evident. The brain and its hemispheres are not at all smaller than those of the *Tarsius*, or of the typical lemurs of the present period. This is important in view of the very small brains of the flesh-eating and ungulate Mammalia of the Eocene period so far as yet known. In conclusion, there is no doubt, but that the genus *Anaptomorphus* is the most simian lemur yet discovered, and probably represents the family from which the true monkeys and men were derived. Its discovery is an important addition to our knowledge of the phylogeny of man.

Char. specif. The specimen is distorted by pressure, but its form is normally nearly round, when viewed from above or below. The extremity of the muzzle is broken away, but the alveolus of the external incisor indicates that it is short, and not prolonged as in *Tarsius spectrum*. The mandibular ramus, already described, proves the same thing. The orbits are large, but not so much so as in *Tarsius spectrum*; their long diameter equals the width of the jaws at the last superior molar teeth inclusive. The supra-orbital borders project a little above the level of the frontal bone, which is concave between their median and anterior parts. The cranium is wide at the postorbital region, in great contrast to its form in the *Adapidæ*, resembling the *Necrolemur antiquus* Filh. in this respect. The postfrontal processes are wide at the basal portion, and flat. From their posterior border the temporal ridges take their origin. These converge posteriorly and probably unite near the lambdoidal suture, but this part of the skull is injured. The anterior lobes of the cerebral hemispheres are indicated externally by a low boss on each frontal bone.

The paroccipital process is short and wide at the base, and it is directed downwards and forwards. The alisphenoid descends so as to form a strong wall on the anterior external side of the otic bulla. This is also the case in *Tarsius spectrum*, but in the extinct species the descending ala is more robust, and has a thickened margin. On the latter the external pterygoid ala rests by smooth contact of its thickened superior edge. This ala is twice as prominent as the internal pterygoid ala. The posterior nareal opening is not wide, and its anterior border is parallel with the posterior border of the last superior molar teeth. The palate is wide, and its dental borders form a regular arcade as in man, being quite different from the form usual in monkeys and lemurs, including *Tarsius*. Perhaps the form is most like that of *Microrhynchus laniger*. The proximal parts of the malar bone are prominent, and overhang the maxillary border, as in *Tarsius*.

The *foramina ovale* and *lachrymale* are rather large. There are two infraorbital canals, lying beside each other, and issuing by two foramina externa. The external appearance justified this conclusion, but the fact

was demonstrated when I accidently broke away the anterior border of one of the orbits. This displayed the two canals filled with matrix their entire length. The anterior foramen externum is anterior to and above the posterior, and both are above the first (third) premolar tooth. The lachrymal foramen is above the space between that tooth and the canine.

The crown of the canine tooth is a cone with a very oblique base, and a convex anterior face. The base rises behind, and the posterior face has on the median line a low angular edge. The internal cone of the third (first) premolar is not so prominent as that of the second, though large. The external cusps of both premolars rise directly from the external base. They are flattened cones, with anterior and posterior cutting edges. The crowns are a little contracted at the middle, so as to be narrower than the inner lobe of the tooth, which is narrower than the external portion. Both premolars have delicate anterior, posterior and external cingula. The external cusps of the true molars rise directly from the external base, and like those of the premolars, have a regularly lenticular section. At the internal base of each one is a small intermediate tubercle, which is connected by an angular ridge with the single internal cusps. There are delicate anterior, posterior, and external cingula, but no internal. The posterior cingulum shows a trace of enlargement at its inner part, which is well marked on the second molar, but it is not as prominent as in many Creodont genera. The posterior external cusp of the last true molar is reduced in size. Taking the molars together, the first true molar is the largest, and they diminish in size both anteriorly and posteriorly. The third true molar is a little smaller than the first (third) premolar. Enamel smooth.

Measurements.	M.
Length of cranium to occipital prominence above par-occipital process, and minus premaxillary bone. .	.0280
Total width at posterior border of orbit, below.	.0240
Length of palate from front of canine tooth	.0116
Width of palate and peunltimate molars	.0125
Length of superior molar series	.0095
" " true molars	.0060
Diameters of crown of canine { anteroposterior.	.0018
{ vertical	.0018
Diameters crown of P-m. iii, { anteroposterior.	.0020
{ transverse	.0026
Diameters crown of P-m. iv, { anteroposterior.	.0020
{ transverse	.0035
Diameters M. ii, { anteroposterior	.0032
{ transverse	.0040
Diameters M. iii, { anteroposterior	.0016
{ transverse	.0028
Diameters of orbit { anteroposterior	.0110
{ vertical (? depressed)	.0078
Interorbital width (least)	.0050

The *Anaptomorphus homunculus* was nocturnal in its habits, and its food was like that of the smaller lemurs of Madagascar and the Malaysian islands. Its size is a little less than that of the *Tarsius spectrum*. The typical specimen was found by Mr. J. L. Wortman in a calcareous nodule in the Wasatch formation of the Big-Horn basin, Wyoming Territory.

Creodonta.

Shortly after the publication of my arrangement of the Creodonta in 1880*, I obtained a good deal of additional material, which enabled me to improve it in several respects. A number of genera have been added, and the characters which distinguish the *Miacidæ* and *Oxyænidæ* have been more fully brought out. The *Miacidæ* differ from all other families in having the fourth superior premolar sectorial as in the true *Carnivora*, while the true molars are tubercular. In *Oxyæna*, the fourth superior premolar displays no indication of sectorial structure, the first true molar assuming that character. In *Stypolophus* and allies, the second superior true molar is more or less sectorial, and the first true molar and even the fourth premolar in some of the genera, develop something of the same character. But there is every gradation between the triangular *Didelphys*-like, and the sub-sectorial *Pterodon*-like forms of the superior molars, in this group of genera.

The glenoid cavity of the squamosal bone presents differences in the various genera of this sub-order. In *Arctocyonidæ* (fide De Blainville), *Oxyænidæ*, and *Mesonychidæ*, it is bounded by a transverse crest anteriorly, as well as by the postglenoid posteriorly, while in the *Leptictidæ* it is plane and open anteriorly. In *Amblyctonidæ* its condition is unknown. In existing *Carnivora* this character is not very constant as a family definition; it is best marked in the *Felidæ*, and least marked in the *Canidæ*. Nevertheless there is a group of genera allied to the *Oxyænidæ*, which are very marsupial in character, which have been called the *Leptictidæ*, and which differ so far as known from *Oxyæna* in the absence of the preglenoid crest. I suspect that these forms constitute a family by themselves, and for the present, until our knowledge of them is fuller, I define it by this character. The definitions of the families will then be as follows:

I. Ankle-joint plane transversely, or nearly so.

True molars above and below, tubercular; last superior not transverse.... *Arctocyonidæ.*

Superior true molars, tubercular; last superior premolar sectorial; first inferior molar "tubercular sectorial"... ..... *Miacidæ.*

Superior last molar transverse; inferior molars tubercular-sectorial or with reduced anterior cusp; no preglenoid crest..... *Leptictidæ.*

Last superior molar trenchant, transverse; first superior true molar sectorial; inferior true molars tubercular-sectorial; a preglenoid crest... *Oxyænidæ.*

* Proceedings Amer. Philos. Society, p. 76.

Last superior molar longitudinal ; inferior true molars without developed sectorial blade.....*Amblyctonidæ*.

II. Ankle-joint tongued and grooved, or trochlear.

Molar teeth in both jaws consisting of conic tubercles and heels ; none sectorial ; a preglenoid crest.....*Mesonychidæ*.

I now give the characters of the genera. All these are derived from examination of typical specimens. The opportunity of doing this I owe to the kindness of Messrs. Leidy, Gervais, Gaudry, Filhol, and Lemoine.

ARCTOCYONIDÆ.

Premolars, $\frac{4}{4}$; the first inferior one-rooted ; the last inferior well developed ; *Arctocyon* Blv.

Premolars below, 4, the first two-rooted, the last true molar much reduced ; (fide Lemoine).....*Hyodectes* Cope.

Premolars below, 3, first two-rooted ; true molars normal..... *Heteroborus* Cope.

MIACIDÆ.

Inferior tubercular molars two, premolars four.....*Miacis* Cope.

Inferior tubercular molars one, premolars four.....*Didymictis* Cope.

LEPTICTIDÆ.

I. Superior molars sub-equilateral, without cutting heel posteriorly.

a. Fourth inferior true molar like the true molars, with three anterior cusps.

β. Third superior premolar with internal cusp ; anterior cusp of inferior molars small, median.

Third premolar with one external and one internal cusps.*Mesodectes* Cope.

Third premolar with two external and one internal cusps....*Ictops* Leidy.

ββ. Third superior premolar without internal cusps ; anterior cusps of inferior molars present.

Cusps of superior molars marginal ; two superior incisors ; *Leptictis* Leidy.

Cusps of superior molars median in position ; anterior cusp of inferior molars well developed.....*Peratherium* Aym.

βββ. Anterior cusps of inferior molars wanting.

Fourth inferior premolar like true molars.....*Diacodon* Cope.

aa. Fourth inferior premolar different from true molars in a simpler constitution.

Last inferior molar tubercular ; cusps of other true molars well developed; three inferior premolars.....*Lipodectes* Cope.

Inferior true molars alike, with anterior inner cusps little developed ; three premolars (?).....*Triisodon* Cope.

Inferior true molars alike, with cusps well developed ; four premolars.... *Deltatherium* Cope.

II. One or more superior molars, with the external heel produced into a blade.

a. Molars 4—3; three last inferior tubercular sectorial.

Premolars robust, conic..... *Quercitherium* Filh.
Premolars compressed; the fourth superior with a conic cusp and heel externally..... *Stypolophus* Cope.
Premolars compressed; fourth superior with a simple blade externally... *Proviverra* Rütim.

OXYÆNIDÆ.

I. Inferior molars without internal tubercles.

Molars, $\frac{4}{3}$ $\frac{3}{3}$; three sectorials in the lower jaw..... *Pterodon* Blv.

II. Inferior molars with internal cusps.

a. Posterior heel of one or more superior molars elongate and trenchant.

Last inferior molar truly sectorial, without internal tubercle; second, tubercular-sectorial..... *Protopsalis* Cope.
Molars, $\frac{4}{4}$ $\frac{2}{2}$; two last inferior molars tubercular-sectorial... *Oxyæna* Cope.

AMBLYCTONIDÆ.

Fourth inferior premolar with a broad heel supporting tubercles; an anterior and no internal tubercles..... *Amblyctonus* Cope.
Inferior molars with tubercular heel, an anterior and an internal tubercle. *Periptychus* Cope.
Dental formula below, 3, 1, 3, 3. Fourth inferior premolar with a cutting edge on the heel; both internal and anterior tubercles..... *Palæonyctis* Blv.

MESONYCHIDÆ.

a. Inferior molars seven;

Cones of inferior and superior molars simple..... *Mesonyx*.
Cones of last two inferior molars with lateral cusps..... *Dissacus*.

aa. Inferior molars ? six.

Internal lobes of penultimate superior molar v-shaped..... *Sarcothraustes*.

aa. Inferior molars five.

Inferior molars with strong anterior lobe..... *Patriofelis*.*

MIACIS CANAVUS Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, p. 189. One mandible.

MIACIS BREVIROSTRIS Cope, loc. cit. p. 190.

Parts of four mandibles.

DIDYMICTIS DAWKINSIANUS Cope, l. c., p. 191.

Six mandibular rami more or less complete.

Individuals of the genus *Didymictis* are abundant in the Wasatch beds

* Of uncertain reference to this family.

of the Big-Horn, and a good many of them do not coincide well in characters with the species already described. I define them as follows, premising that with other parts of the skeleton some changes may be found to be necessary. The large *D. altidens* was not obtained by Mr. Wortman in the Big-Horn country.

I. Inferior tubercular molar oval in outline, with a heel.

Length true molars .010 ; last three premolars .0135 ; last molar narrow.. *D. dawkinsianus.*

Length true molars .016—.018 ; last three premolars .028—.030 ; last molar narrow.....*D. leptomylus.*

Length true molars .019—.020; last three premolars .036 ; last molar elongate.....*D. protenus.*

Length true molars .025 ; last three premolars .035 ; last molar short..... *D. altidens.*

II. Inferior tubercular molar short, subquadrate in outline.

Length true molars .011 ; depth of ramus at sectorial .010..... *D. massetericus.*

Length true molars .018 ; depth of ramus at sectorial .017....*D. curtidens.*

Didymictis leptomylus Cope.

American Naturalist, 1880, p. 908.

The specimens which I refer at present to this species belong to two varieties, which may perhaps be specifically distinct ; but this cannot be demonstrated at present. They differ in dimensions only. Thus the true molars of the type, which comes from the Big-Horn beds, measure M. .016 in length. Five specimens from the Big-Horn basin agree in having this dimension .018. The entire inferior molar series is only a little shorter than that of the smaller variety of the *D. protenus* from New Mexico (See my report to Capt. Wheeler, plate xxxix).

Didymictus protenus Cope.

Jaws more or less complete, of six individuals, are referable to this species. They agree closely in measurements and belong to the larger variety of the species figured on plate xxxix of the report to Capt. Wheeler.

Didymictis massetericus, sp. nov.

This species is intermediate in size between the *D. leptomylus* and the *D. dawkinsianus*, and is characterized by the peculiar form of its tubercular molar, and the deeply excavated masseteric fossa. It appears to have been a rare species, as only one mandibular ramus was found by Mr. Wortman. This is broken off in front of the fourth premolar, and supports the last true molar teeth.

The tubercular molar is subquadrate in form, and consists of three low tubercles in front, and a wide heel behind, which has an elevated posterior border. The tubercular-sectorial has a short and narrow heel. Its anterior cusps are not very acute, and the two internal are equal, and a good deal

shorter than the external. The fourth premolar is relatively shorter than in any other species of the genus, and the posterior marginal lobe is a mere thickening of the edge of the heel. There is a low anterior basal tubercle. The enamel is smooth.

The ramus is compressed and not deep. The angle is prominent, and is not inflected; it does not extend so far posteriorly as the posterior border of the condyle. The inferior border of the masseteric fossa is an angular line, without abrupt excavation, but the face of the fossa descends rapidly. The anterior border of the fossa is abrupt and is formed by the usual subvertical ridge.

Measurements.	M.
Length between P-m. IV, and condyle inclusive	.0520
" of posterior three molars	.0170
" of tubercular-sectorial	.0070
Elevation of " "	.0070
Depth of ramus at sectorial	.0100

DIDYMICTIS CURTIDENS, sp. nov.

As in the case of the *D. massetericus* the present species is represented by a single fragmentary mandibular ramus. This supports a sectorial tooth of the size and form of that of the *D. protenus*, and is thus much larger than that of the species just named. This tooth is placed nearer to the base of the coronoid process than is seen in any other species, and only leaves space for a short tubercular tooth. This is lost from the specimen, but the alveolus shows pretty clearly its dimensions. The base of the fourth premolar remains, and it is evident that this tooth was like that of *D. protenus* in form and proportions. The base of the posterior marginal lobe is present. The ramus is deeper and larger than in the *D. massetericus*.

Measurements.	M.
Length of bases of last three molars	.0285
" " fourth premolar	.0120
" " of sectorial on base	.012
Width " in front	.008
Depth of ramus at sectorial	.017

ICTOPS BICUSPIS Cope. Bull. U. S. Geolog. Surv., Terrs. 1881, p. 192.

This mammal was founded on a skull from the Wind River region. It is now represented by a mandibular ramus. The form of the fourth premolar being unknown, its reference to this species is provisional only. It may be remotely allied to *Stypolophus*, but the anterior inner cusp of the molars is small and does not reach the inner side of the crown, and the anterior external cusp is but little larger than the second anterior inner. The two cusps last named stand opposite to each other, and their apices are only separated from each other by an open notch. They, with the first anterior inner (here median), form a transverse narrow triangle. The posterior part of the crown is rather large and, though lower than the anterior part,

is absolutely quite elevated above the alveolar border. Its summit presents a V externally, and there is a small posterior median angle. In the last true molar this angle is a little more prominent than in the others, and rises into a cusp. The external bases of the crowns are protuberant, but there are no cingula. Enamel smooth.

The ramus is rather compressed, and the masseteric fossa is well marked, and is bounded anteriorly by a prominent rib.

Measurements.		M.
Length of true molars		.0100
Diameters M. III	anteroposterior	.0035
	vertical	.0035
	transverse	.0030
Diameters M. I	anteroposterior	.0035
	transverse	.0028
Depth of ramus at M. II		.0070

This species is smaller in all dimensions than *I. didelphoides*, and the crowns of the molar teeth are shorter and more elevated than in that species.

DELTATHERIUM ABSAROKÆ Cope. American Naturalist, 1881, p. 669.

A small species, represented by an imperfect cranium and lower jaw with nearly complete dentition.

STYPOLOPHUS ACULEATUS Cope.

Several fragmentary mandibles nearly coincide in measurements with this species. The molars are .0240 in length, and the ramus is .0140 in depth. The only difference in the measurements is that the true molars measure .0250 in *S. aculeatus*. The latter is, however, a species of the Bridger epoch, so that further comparison will be necessary before identification is made.

STYPOLOPHUS WHITIÆ, sp. nov.

Stypolophus strenuus Cope. Bulletin U. S. Geol. Survey, VI, 192; not of Report Capt. Wheeler, vol. IV, pt. ii.

The greater part of the skeleton, with skull and dentition of this species, were brought from the Big-Horn by Mr. Wortman. A part of a mandible of a second individual was also found. The species is, however, primarily based on a specimen from the Wind river. This is represented by a right mandibular ramus which supports all the molar teeth, and displays the alveolus of the canine, and lacks all posterior to the coronoid process; also by a portion of the frontal bone, two vertebræ, fragments of scapula, humerus, ulna, radius, ilium, and tibia, and the greater part of both tarsi. They represent a species larger than the Virginian opossum, and intermediate between the *S. brevicalcaratus* and *S. strenuus* in proportions. It has not the rudimental heels of the molars of the former species, nor the robustness of the latter.

The inferior outline of the mandible is gently curved from the canine

to below the last molar. The anterior border of the masseteric fossa is well marked, but not the inferior border. The ramus is compressed and deep. The canines have stout roots and narrow curved crowns. The first premolar is separated by a short space from the canine and by a longer one from the second premolar. It has either a single compressed root or two roots confluent within the alveolus. The crown is truncated obliquely behind. The second premolar is two-rooted and the crown is elevated anteriorly and depressed posteriorly. The third premolar is more symmetrical, but the heel is produced. It is narrow and keeled medially. The fourth premolar is abruptly larger than the third. Its crown is simple, except a low tubercle at the anterior base and a short trenchant heel at the posterior base. Of the three tubercular-sectorials the first is the smaller. The heels of all three are rather narrowed and elongate. Their margin is raised all round, inclosing a basin ; a notch in the external margin cuts its anterior part into a tubercle. The two internal tubercles are rather obtuse, and are considerably shorter than the external cusp.

Measurements.	M.
Length from canine to end of last molar	.060
" " " first true molar	.037
" " " second premolar	.015
" of base of fourth premolar	.009
Elevation of fourth premolar	.007
Length of base of second true molar	.007
" heel " " "	.006
Elevation of second true molar	.009
Depth of ramus at third premolar	.015
Length of superior canine	.028
" crown of superior canine with enamel	.012

A portion of the frontal bone shows weak anterior temporal ridges uniting early into a sagittal crest, which is low as far as preserved. The parietal bones overlap the frontal as far forwards as the temporal ridges. Anterior to the latter the front is concave in transverse section. Viewed from below, the spaces for the olfactory lobes are large and entirely anterior to those which received the anterior lobes of the hemispheres ; each one is about as wide as long. In the small part of the cerebral chamber wall left, there is no indication of convolutions, which would be visible in a gyrencephalous brain ; two air-chambers in front of each olfactory lobe.

The base of the transverse process of the atlas is perforated from behind to the middle of its inferior side ; from the latter opening a foramen penetrates directly into the neural canal. A posterior dorsal vertebra has the centrum longer than wide and much depressed. Its inferior face is regularly convex in section. The proximal end of the scapula shows that its inner border is much thickened, and that the spine arises abruptly and near to the glenoid cavity. There appears to have been scarcely any coracoid ; the surface adjoining it is, however, injured. The humerus lacks

the proximal portion and the inner half of the condyles with the epicondyles. The deltoid crest is not very prominent, so that the shaft is rather slender. The external distal marginal crest is thin, and is continued well up on the shaft. The external part of the condyle displays no intertrochlear ridge. Olecranar and coronoid fossæ well marked. The olecranon is robust and deep, and is truncate posteriorly and below. The head of the radius is a regular transverse stout oval.

A fragment of the ilium from near the acetabulum displays a prominent "anterior inferior spine." The best preserved tarsus includes calcaneum, astragalus, cuboid, and navicular bones. The tibial face of the astragalus is strongly convex antero-posteriorly and slightly concave transversely. The head is prolonged some distance beyond the distal extremity of the calcaneum, and presents a convex internal border and a concave external one. Its long axis is parallel to that of the tibial portion, but is not in the same axis, owing to its lateral position. The external face of the trochlear portion is vertical, and is interrupted by a deep fossa behind. The internal face is very oblique, and becomes the superior face of the head. The posterior face of the trochlea is grooved with a wide and shallow grove, which just reaches the superior face, terminating on the external side. The superior face is not grooved, but is shallowly concave in transverse section. The head is a transverse oval, and is convex ; it has a small facet for the cuboid on the outer side.

The heel of the calcaneum is large and expands distally, so as to be as wide as deep. The convex astragalar facet is very oblique to the long axis of the calcaneum ; the sustentaculum is rather small. Below the latter is a narrow tuberosity looking downwards and forwards. On the external side, close to the cuboid facet, is a depressed crest. The cuboid facet is as deep as wide. The cuboid bone is a little longer than wide proximally, and narrows distally. It has a narrow astragaline facet and a deep fossa below proximally. The hook inclosing the groove for the tendon of the flexor muscle is prominent. The navicular is rather small, and has three inferior facets, which diminish in size outwards. It has a strong posterior knob-like process, with a narrow neck.

When the tarsal bones are in position, and the tibia stands vertically on the astralagus, the cuboid bone is turned interiorly. This indicates that this species walked on the outer edge of the hinder foot.

Broken metapodial bones are slender and straight. The proximal end of a metacarpal does not display the interlocking lateral articulation seen in *Protopsalis*. Two phalanges are depressed in form.

Measurements.		M.
Diameters of a dorsal centrum	anteroposterior	.0145
	vertical	.0075
	transverse	.0115
Diameters of glenoid cavity scapula	anteroposterior	.0145
	transverse	.0090

Measurements.	M.
Depth of olecranon	.0110
Width of head of radius	.0110
" neck of ilium anteroposteriorly	.0120
Diameter of shaft of tibia at middle	.0085
Diameters of astragalus: anteroposterior	.0180
Diameters of astragalus: greatest	
Diameters of astragalus: transverse. of trochlea	.0140
Diameters of astragalus: transverse. of head	.0100
Length of head	.0070
" calcaneum	.0300
Width of calcaneum at sustentaculum	.0140
" cuboid facet	.0066
Length of cuboid	.0120
Diameters: anteroposterior distal	.0070
Diameters: anteroposterior proximal	.0075
Diameters: transverse proximal	.0098
Diameters of navicular: vertical	
Diameters of navicular: transverse with tuberosity	.0100
Diameters of navicular: transverse without tuberosity	0070
Diameters of navicular: anteroposterior	

As already remarked, it is probable that the semigrooved trochlea of the astragalus of this species is an indication that the genus *Prototomus* must be retained as distinct from *Stypolophus*, to which the present species probably truly belongs.

The specimen described, together with the mandibular ramus of another supporting the last two molar teeth, were found in the bad lands of Wind river, Wyoming, by J. L. Wortman. Dedicated to Frances Emily White M. D., of Philadelphia.

OXYÆNA FORCIPATA Cope.

Report Vert. Foss., New Mexico, 1874, p. 12. Report Capt. G. M. Wheeler, U. S. G. G., Expl. Surv. W. of 100th Mer. IV, ii, p. 105, 1877.

This formidable animal was abundant in Northern Wyoming, during the Wasatch epoch. At least ten individuals are represented in the collection. The following are the dimensions of the mandibles of the five best preserved.

	1	2	3	4	5
Length of dental series	.103	?	.100	.100	.107
" premolar "	.042	.045	.044	.051	.054
Depth of ramus at M. III	.042	.039	.037	.042	.047

The measurement .035 for the length of the premolars given in my report to Capt. Wheeler, loc. cit., refers to the anterior three teeth, which were originally supposed to be the only premolars.

The claws of this species are moderately compressed, and they terminate abruptly and obtusely. The extremity is deeply fissured, and each of the two apices is rugose.

Mesonyx ossifragus Cope, American Naturalist, 1881, p. 1018.

Pachyæna ossifraga Cope. Report Capt. Wheeler, U. S. G. G. Surv. W. of 100th Mer. iv, ii, p. 94, 1877.

A series of specimens of this species demonstrates the following points: (1) *Pachyæna* was founded on a superior molar of *Mesonyx*, and must be suppressed. (2) *Mesonyx navajovius* Cope must be separated as a distinct genus, since the apices of the crowns of the last two molars have two cusps. I have called this genus *Dissacus* (American Naturalist, Dec., 1881). (4) It results that there are three species of *Mesonyx*: *M. ossifragus* Cope, *M. lanius* Cope, and *M. obtusidens* Cope.

M. ossifragus was the largest Creodont of the Eocene, equaling the largest grizzly bear in the size of its skull. In a cranium with lower jaw and almost complete dentition, the length to the premaxillary border from the postglenoid crest is M. .365; the largest *Ursus horribilis* in my collection gives .270 for the same length. This specimen has the dental formula I. $\frac{3}{2}$; C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$. The claws have the flattened form which I discovered in *M. lanius*, and the proximal phalanges have much the shape of those of a Perissodactyle. The astraglus has much the character of the animals of that order, and has the distal facets as I originally detected them in the *M. obtusidens*. The form of this bone is rather shorter and wider than in the latter species.

The inferior canine tooth of a large specimen has the following diameters at the base of the crown: anteroposterior .039: transverse .024.

AMBLYPODA.

Pantodonta.

The explorations in the bad lands of the Big-Horn river yielded several species of this sub-order, all which I refer at present to the *Coryphodontidæ*. They, however, represent several genera, two of which have not been previously known. I have distinguished these (American Naturalist, Jan., 1882), in the characters of the superior molar teeth as follows:

I. Last superior molar with two interior cusps.

All the superior molars with a well marked external posterior V..... *Manteodon.*

II. Last superior molar with but one inner cusp or angle.

a. Last superior molar with posterior external cusp.

Anterior two molars with posterior external V.....*Ectacodon.*

aa. Last superior molar without external posterior cusp.

† Anterior two molars with posterior external V.

Astralagus transverse, with internal hook..... *Coryphodon.*

Astragalus subquadrate, without internal hook..... *Bathmodon.*

††First superior molar only with posterior external V.....*Metalophodon.*

The type of *Manteodon* is the *M. subquadratus*, which was about the size of an ox. The characters of its superior molars are more like those of Perissodactyles than are those of the other *Coryphodontidæ*. The type of *Ectacodon* is the *E. cinctus*, a species of about the dimensions of the last named. Its last superior molar is parallelogrammic, and has a cingulum all around it except on the external side.

MANTEODON SUBQUADRATUS, gen. et sp. nov.

Char. gen. These have been already pointed out in the key above given. They are a little more like those of the superior molar teeth of such *Perissodactyla* as *Limnohyus* and near allies, than those seen in the typical *Coryphodon*. The posterior transverse crest of that genus is here represented by a complete V, but the anterior lobe of that crest which represents the anterior V of the Perissodactyle, is only a lobe, as in *Coryphodon*. The tooth in fact is much like the penultimate molar of the latter genus. The two internal cusps are unique in the family. The additional one is a growth of the inner extremity of the posterior cingulum, and is separated from the anterior inner cusp by a deep and wide notch. It is opposite to the posterior V, as the anterior inner cusp is opposite the anterior rudimental V. The premolar and incisor teeth are similar to those of *Coryphodon*. The skeleton is unknown.

Char. specif. These are learned from a series of teeth which were found together by Mr. Wortman free from admixture of others. They are not worn, excepting by moderate use of the animal when living.

The last superior molar is not of the oval form belonging to the species of *Coryphodon*, but is quadrate, with the internal side shorter and with rounded lateral angles. The first anterior cingulum, which represents the anterior basal cingulum of the *Lophiodontidæ*, is as elevated as in the species of *Coryphodon*. Externally it rises in a protuberance with sharp edge, which curves posteriorly and disappears on the external side of the crown. The inner extremity terminates abruptly, forming the anterior interior tubercle. The anterior external lobe is rather flat, and is not conical nor elevated above the anterior cingular lobe. It is not deeply separated from the latter, nor from the posterior V; its edge is rough. The posterior V projects well inwards, and is rather narrow. Its posterior border extends as far outwards as the point of junction of its anterior border with the anterior external lobe, and terminates in a slight elevation of its border. The base of the crown extends external to the base of the V, and forms a strong posterior external protuberance. This causes the outline of the external base to be concave. This side of the crown has several small protuberances and rugosities. The posterior basal cingulum extends as far externally as the posterior V, and terminates internally in the posterior internal cusp. The second or basal anterior cingulum is well developed. There are no external nor internal cingula. The surface of the enamel is strongly and closely rugose where not worn.

The posterior inferior molar exhibits a transverse posterior crest, without

any tubercle or ridge in the mouth of the posterior V-shaped valley. There is a strong posterior cingulum, amounting to a narrow heel. As in the case of the superior molar, the enamel where not worn is closely and strongly wrinkled. The first superior premolar is characterized by the very small development of its internal lobe, which is only a strong basal cingulum. The crown proper has a sub-triangular outline, and the external face is flat and not concave. No external cingulum; enamel wrinkled. An external incisor has a large transversely extended crown, without cingula. A low rib on the median line of the inner side. Enamel wrinkled. In this and in another incisor, the base of the crown is considerably expanded laterally.

Measurements.		M.
Diameters of crown M. III, sup.	anteroposterior	.035
	transverse	.041
	vertical	.020
Width of M. III inferior, posteriorly		.022
Diameters P-m. I sup.	anteroposterior	.018
	transverse	.014
Diameter base crown I, II		.024
Length crown I, II		.019
Width base crown I, III		.026

ECTACODON CINCTUS, gen. et sp. nov.

Char. gen. In *Ectacodon* the last superior molar has more of the elements of a posterior external V than in *Coryphodon*, but not so much as in *Manteodon*. The posterior transverse crest, it is true, has no oblique posterior ridge joining it, to form with it more or less of a V. But the external posterior angle of the crown supports a cusp, homologous with the vertical rib found at the basal or external angles of the Vs in *Palæosyops* and allied genera, and indicating the outlines a V which lacks its posterior side, in a manner not seen in *Coryphodon*. The penultimate and ante-penultimate superior molars are like those of the latter genus. Skeleton unknown. I have a single species of this genus.

Char. specif. Six superior molars of one skull represent this species. They belong to a large animal, one about the size of the *Manteodon subquadratus*. The last superior molar has a characteristic outline. It is not oval as in the species of *Coryphodon*, nor quadrate as in *Manteodon* sp., but sub-parallelogrammic. The transverse diameter exceeds the anteroposterior, and the anterior and posterior sides are parallel. The external outline is slightly oblique and slightly notched in the middle. The internal border is regularly rounded. The basal or second cingulum extends entirely round the tooth from the posterior external cusp, round the inner base to the anterior external base of the crown; being absent only from the external base. The first cingula both anterior and posterior are well developed as in the species of *Coryphodon*, and unite in the prominent internal angle. The posterior first cingulum joins the posterior basal cin-

gulum at the middle of its length. The anterior first cingulum extends to the anterior external part of the crown, and then turns downwards and posteriorly and terminates at the middle of the external base. The posterior crest is not transverse, but quite oblique, sloping at an angle of 45° with the axis of the jaw. The part of the crest which represents the posterior V is a good deal larger than the part representing the anterior V, and is closely joined with it. The latter is well separated from the anterior first cingular ridge and its anterior exterior elevated portion. The enamel of this tooth is finely wrinkled, and is more readily worn smooth than in the *Manteodon subquadratus*.

The penultimate superior molar has the posterior V well developed, and its posterior basal or external angle is marked by a tubercle homologous with that which is so prominent on the last molar. The anterior V is a conic tubercle closely joined with the posterior V, and well separated from the anterior first cingular lobe. The basal cingular are well developed, but do not meet on the inner base of the crown. The first or superior cingula meet as usual in an interior angle, but there is a contraction of the anterior crest just before reaching this angle. The first true molar is smaller than the second and has the same general structure. Here, however, the anterior first cingulum is more prominent near the internal angle than the posterior. The characters of the premolars do not differ from the corresponding ones of species of *Coryphodon*. The enamel is delicately wrinkled. The first superior premolar is not preserved.

Measurements.		M.
Diameters of crown of M. III	anteroposterior	.034
	transverse	.043
	vertical	.015
Diameters M. I	anteroposterior	.028
	transverse	.033
	vertical	.012
Diameters P-m. III	anteroposterior	.023
	transverse	.030

It is probable that this species was about the size of an ox.

CORYPHODON ANAX, sp. nov.

Mr. Wortman sends me a number of teeth of probably two individuals, which exceed in size those of any species of *Coryphodon* yet known, and differ in certain details of form from all of them. The specimens consist of incisors, premolars and molars of both jaws of one animal, and an interior canine, which from its separate wrapping, I suppose to have been derived from a different locality.

The incisors and premolars have the form usual in species of the genus, differing only in their large size. The same may be said of the premolars. A well preserved superior true molar is probably the third. It has the form usual in the genus, but exhibits two peculiarities. The posterior transverse crest is divided more deeply than usual by a deep notch which

enters it from the transverse valley. The external portion is the shorter, and exhibits the peculiarity of being connected with external part of the anterior transverse crest. It is as closely connected with this crest, as it is with the internal portion of the posterior crest. The external connection does not exist in the other species of the genus, where the two crests are separated at their outer extremities by a deep valley. The posterior basal cingulum is obsolete, while the anterior is well developed. The enamel of this tooth where not worn, is wrinkled.

The posterior part of the last inferior molar is characteristic. The posterior transverse crest is short and very oblique, its inner extremity striking the posterior margin near the middle. Here it is elevated into a cusp, which rises above the surrounding parts in a characteristic manner. There is no ledge round its posterior base, but the border expands outwards at the base of the true crest. The additional inner marginal tubercle is low and compressed as in *C. lobatus*. A second inferior true molar is normal, with well developed anterior marginal ridge. The inferior canine mentioned is of large proportions, exceeding by one-half the dimensions of the inferior canine of *C. lobatus*. Its crown is curved outwards, and has a basal alate expansion of its internal ridge.

Measurements]		M.
Diameters of last superior molar	anteroposterior	.039
	transverse	.051
Diameters of second inferior true molar	anteroposterior	.039
	transverse	.028
Length of inferior canine		.160
" crown of "		.090
Diameters of base of crown of canine	vertical	.037
	transverse	.036

This species is nearest the *C. lobatus* in some respects. The short posterior crest of the last inferior molar with its cusp-like extremity, and the absence of posterior ledge on this tooth will readily distinguish it.

Bad lands of the Big-Horn river, Wyoming.

There are six individuals of this species in the collection which are mostly represented by fine specimens, which represent the entire dentition.

Eight other species of *Coryphodon* were obtained by the Big-Horn Expedition, and the material enables me to distinguish them better than heretofore. I present the following differential synopsis of their characters.

I. The last inferior molar with three posterior cusps, the internal sometimes represented by a ridge; or the posterior inferior molars with an accessory cusp or tubercle on the inner side between the crests (*Coryphodon*, Owen):

An internal tubercle; last upper molar with the anterior cross crest and anterior external crest closely connected; size largest..... *C. anax.*

An internal conic cusp; posterior crest oblique; heel very small; size medium.. ..... *C. cuspidatus.*

An internal crest; posterior crest oblique; heel small; size medium..... *C. obliquus.*

An internal tubercle; posterior crest little oblique; heel large; size large. *C. lobatus.*

II. Posterior inferior molars with two posterior cusps; without internal accessory tubercle:

a. Posterior inferior molars with small or no heel:

Large; posterior superior molar oval, with distinct straight posterior crest; inferior molars elongate; symphysis mandibuli produced and narrowed; premaxillary elongate..... *C. latipes.*

Medium; inferior molars nearly as wide as long; premaxillary short..... *C. latidens.*

aa. Posterior inferior molars with prominent or wide heel:

Medium; posterior superior molar with posterior angle, and angulate posterior crest; inferior molars elongate; symphysis mandibuli broad and short; premaxillary elongate; tusk trihedral.... *C. elephantopus.*

Smaller; premaxillary bone short; tusk trihedral..... *C. simus.*

Medium; premaxillary elongate; tusk compressed and grooved..... *C. molestus.*

Large; last superior molar oval, with angulate posterior crest; its anterior lobe connected with anterior cingular crest..... *C. repandus.*

III. Last inferior molar with but one posterior cusp from which a curved crest extends round the posterior border of the crown.

Superior true molars narrow; external incisors sharply angulate on external face..... *C. curvicristis.*

IV. Posterior inferior molar unknown.

Posterior superior molar oval; posterior crest straight; internal crest fissured (? normally); a complete internal cingulum... *C. marginatus.*

CORYPHODON CUSPIDATUS Cope.

This species was found in a single individual obtained in New Mexico; a second one was discovered by Mr. Wortman in the Wind River basin, and a third has now been brought from the Big-Horn.

CORYPHODON LATIPES Cope.

I refer seven individuals provisionally to this species. Three of these are represented only by superior teeth, etc., and in four the last inferior molar is preserved. Of the latter, three have an angle, sometimes almost a crest, descending from the posterior inner tubercle, as in *C. obliquus*, but the specimens are all of superior size to that species, some of them very much exceeding it. It is also possible that this ridge is not a constant character. This species has the dentition which I have referred to the *Bathmodon radians*, but no astragalus of the species occurs in the collection. It may be the *C. latipes*, of which the teeth have not yet been identified. I hope soon to be able to decide this question.

CORYPHODON SIMUS Cope.

A broken mandible and maxillary bone, with several teeth represent this small species in the Big-Horn collection.

CORYPHODON ELEPHANTOPUS Cope.

Portions of the dentition of both jaws, including the last molar teeth of two individuals, prove that this species inhabited Wyoming in the early Eocene period. One of the individuals, represented only by the last molars of both jaws, is a little smaller than the typical specimen of which an entire cranium is figured in Capt. Wheeler's report (4to, 1877, Pl. LI–III), while a second specimen, which includes the entire superior molar series, is a little larger than the same.

This species is characterized by the obliquity of the edge of the posterior crest of the posterior superior molar backwards away from a transverse line; and by the slope of the external side of this crest. In other words the inner half of the posterior crest nearly forms a V, like that of the penultimate molar. The posterior edge of the V is present, running outwards from the inner end of the posterior crest, which thus becomes the apex of the V. The *C. elephantopus* thus most nearly approaches the genus *Manteodon*, of all the species. To accommodate the obliquity of the crest the posterior outline of the last upper molar is strongly angulate, giving a sub-triangular outline. The heel of the last inferior molar is insignificant.

CORYPHODON REPANDUS, sp. nov.

This large species is known from the posterior portions of the dentition of both jaws, with an entire symphysis.

The last superior molars are intermediate in outline between the regular oval of the *C. radians*, and the sub-triangular form of the *C. elephantopus*. The peculiarities of the species are seen in the posterior crest. The two lobes of which this is composed, do not form a continuous line as in *C. latipes* and *C. simus*, but form an angle with each other as in *C. anax*. The anterior lobe is compressed, and its long axis is nearly that of the jaw; the second lobe leaves it at a right-angle, but curves backwards as it extends inwards, giving a concave exteroposterior border. There is no ridge descending outwards from the inner extremity of the crest, to form a V, as in *C. elephantopus*. But the posterior basal cingulum extends to the external side of the tooth, which is not the case in any other species known to me excepting the *C. marginatus*. The anterior cusp is closely joined to the external elevation of the anterior first cingulum as in *C. anax;* a character which separates it from all other species. A strong trace of a cingulum passes round the inner base of the crown. No external cingulum. The first true molar does not differ materially from that of other species. It is considerably smaller than the last. The apex of the premaxillary bone with the second incisor and alveolus of the first, is preserved. The bone is rather short. The crown of the incisor is regularly convex ex-

ternally, and is not expanded at the base. There is a strong internal cingulum.

A fragment of the lower jaw supports the last two molars. The internal angle of the last one, is unfortunately broken. The posterior crest is, however, perfectly transverse, which is not the case with the species with three posterior tubercles. The preserved part of the posterior border shows a distinct, rather narrow heel. The anterior Vs are well developed and there are no lateral cingula. The symphysis is flattened out by pressure. The inferior canine is large. It is sub-triangular at base and has an anterior basal angular projection.

Measurements.		M.
Diameters of superior M. III	transverse	.046
	longitudinal	.037
Diameters of superior M. I	transverse	.036
	longitudinal	.032
Diameters crown I. 2	vertical	.018
	transverse	.018
Diameters inferior M. III	transverse	.028
	anteroposterior	.040
	vertical in front (restored)	.024
Length of symphysis		.107
Depth of ramus at M. III		.056

The superior molars of this species might readily be taken for an undersized individual of *C. anax*, but the last inferior molar is of a different type, and refers the species to a different section of the genus.

CORYPHODON CURVICRISTIS, sp. nov.

The fragments which represent this species belong to one individual. They include a considerable part of both mandibular rami with numerous molar teeth, and most of the inferior incisors loose. Also the second superior molar, some superior premolars, the canine, and three or four incisors, two of them in place in an incomplete premaxillary bone. None of the bones of the skeleton were obtained, so far as known.

The ramus of the mandible is both robust and deep. Its inferior border does not rise posteriorly so much as in some species, as *e. g.*, *C. latidens*, and the angle is well below the horizontal line of the dental alveoli. The dental foramen is just about in this line. The inferior premolars and molars do not differ from those of several other species, but the last molar has several peculiarities. The external cusp is the only one of the posterior pair which is present. It gives origin to two crests, both of them curved. The posterior represents the usual posterior transverse crest, but is gently convex backwards, and turns forwards on the inner side of the crown, only terminating at the external base of the anterior cross crest. The other curved crest is low, although higher than in most species, and extends to the middle of the base of the anterior cross crest. There is a distinct heel which is elevated at the middle and disappears gradually at each end, not being abruptly incurved as in *C. anax*. The anterior part of this

tooth is as peculiar as the posterior. The external cusp gives origin to three crests, two of them the usual limbs of the anterior V; while a third descends to the anterior border a little exterior to its middle. It encloses a deep groove with the anterior ridge of the anterior V. This arrangement is not seen in any other species.

The inferior canine is robust, and has its anterior angle prominent, but not alate. The crowns of the inferior incisors are regularly convex exteriorly, and have no cingula. They are regularly graded in dimensions.

The superior molar preserved is probably the penultimate. Its anterior portion is broken. The posterior external V is narrower than usual for a second molar, and resembles somewhat that of the last superior molar of the *Manteodon subquadratus*. A slight contact face on the posterior cingulum shows that this tooth is not the last molar. The said cingulum extends to the external base of the V; in rising to the internal cusp it forms a sigmoid curve. The cingulum below this, on the inner base of the crown, is rudimental. The superior canine has a long and robust crown, with a triangular section to the apex. The posterior face is a little wider than the other two, which are equal. The anterior is slightly concave in cross-section, and the posterior slightly convex transversely, although concave longitudinally. There is a weak ridge nearly parallel to and near the postero-external angle, and traces of others on the postero-external face of the crown in front of this one. The antero-internal angle is swollen at the base.

The superior incisors present characteristic features. The ridge of the external face, which is weakly developed in some of the species, and is wanting in others, is here represented by a strong longitudinal angle, which extends from the base of the crown to its apex, dividing the external face into two distinct planes. This character is most marked on the external incisor, where the planes are sub-equal, and concave. On the second the anterior plane is smaller, and on the first it is a good deal smaller. These incisors have a weak internal cingulum, but no external one.

Measurements.	M.
Length of ramus from P-M. IV inclusive	.257
" inferior true molars	.098
Diameters of M. I infer. { anteroposterior	.0275
Diameters of M. I infer. { transverse	.020
Diameters of M. III infer. { anteroposterior	.036
Diameters of M. III infer. { transverse	.029
Depth of ramus at M. III	.075
Diameters of M. II super. { anteroposterior	.0315
Diameters of M. II super. { transverse	.039
Diameters of crown of superior canine { longitudinal	.094
Diameters of crown of superior canine { anteroposterior	.022
Diameters of crown of superior canine { transverse	.034
Diameters of crown of I. iii { vertical	.022
Diameters of crown of I. iii { transverse	.024

The numerous characteristic marks, show that this species is one of the most distinct of the genus. It is also one of the largest, being second only to the *C. anax.*

CORYPHODON MARGINATUS, sp. nov.

This is one of the smaller species, having nearly the dimensions of the *C. molestus.* It is only represented by the superior canine, first inferior premolar, and last superior molar of one individual found together by Mr. Wortman. Their size, mineral condition and degree of wear, render it probable that all belong to one individual.

The superior molar is of the oval type, without posterior shoulder. The posterior crest is therefore straight, and parallel with the anterior crest. Its inner extremity does not display the least tendency to form a V, as is seen in *C. elephantopus.* Its exterior extremity is widely separated from the external prominence of the anterior crest (cingulum). The latter displays, at its inner extremity, the peculiarity of a deep fissure of the anterior side, which nearly divides the crest, and partially isolates the internal tubercle. Adjacent to the fissure its crest is tuberculate. The posterior upper cingulum descends from the inner cusp to the basal cingulum. The basal cingulum is well developed on the anterior and interior sides of the crown, and on the posterior as far as the base of the inner cusp of the posterior crest, where it gradually fades out. Enamel wrinkled.

The superior canine is remarkable for its small size. The posterior face is a little the widest, and its bounding edges are sharp, but not expanded. There are no prominent ridges of the enamel. The anterior face is moderately wide. The first inferior premolar presents no peculiarities.

Measurements.		M.
Diameters of M. III superior	anteroposterior	.028
	transverse	.038
	vertical	.019
Diameters of P-m. I inferior	anteroposterior	.015
	transverse	.009
Diameters of C. superior	anteroposterior	.014
	transverse posterior	.018

The superior molar is but little worn, and shows that the animal was just adult. The canine is more worn than the molar.

There are several characters which mark this species as distinct from those previously known. It is the only member of the genus which has a complete internal cingulum. The fissure of the anterior crest, if normal, is peculiar to this species. The superior canine is disproportionately small.

Besides the *Coryphodons* already mentioned, a number of more or less complete skeletons were obtained, some of which can be identified by comparison with those which are accompanied by teeth, and which are enumerated in the preceding pages.

METALOPHODON TESTIS, sp. nov.

The genus *Metalophodon* was described by me in 1872.* Since that time it has remained without further illustration of importance, as no good specimens of it have been obtained by any of my expeditions up to the present year. Thy material now at hand consists of the entire superior molar series of the right side, and the superior molars of the left side, in beautiful preservation. These display the characters on which the genus was proposed, *i. e.*, the conversion of the posterior external V of the second true molar into a transverse crest similar to that of the last true molar. It follows that the first true molar is the only one which exhibits this V. It also follows that in this genus the peculiarities of the dentition of *Coryphodontidæ* are carried further than in *Coryphodon*, where two molars display the V, and one the crest; or than in *Manteodon*, where all three have a V, and none the crest. The genera then stand in the order of evolution, *Manteodon*, *Coryphodon*, *Metalophodon*.

Char. specif.—The first superior premolar has lost its crown. The other premolars do not display any marked peculiarities. The internal cusps are well developed, and are most prominent posterior to the line of the apex of the exterior crest. They connect with the posterior cingulum by a broad ledge, but do not connect with the anterior cingulum. The two cingula nearly connect round the inner base of the crown on the third premolar.

The first true molar is well worn. The base of the posterior external V can be seen, and the anterior and posterior cingula. There is no internal cingulum. The second true molar is the largest of the teeth. It is subtriangular in outline, its external side forming with the posterior, a right angle. Its general character is much like that of the Coryphodontes, but it presents the remarkable exception which constitutes the character of the genus *Metalophodon*. The posterior crest does not include a V, but is straight, and consists of the same elements as the posterior crest of the third true molars, but differently proportioned. The part representing the anterior V is a cone, much shorter than the part corresponding to the posterior V. As there is a postero-exterior angle of the crown there is an oblique surface rising to this part of the crest, which represents the external face of the V. There is also a small tubercle at the angle, where a similar one is found in the corresponding tooth of *Ectacodon cinctus*. Altogether this tooth is like the posterior molar of *Coryphodon elephantopus*, with a more prominent postero-external angle added. The anterior and posterior basal cingula are well developed, the latter being strong interiorly to the point where it sends a branch upwards to the internal cusp. There is no internal cingulum.

The last superior molar is a transverse oval, more regular than usual in the species of *Coryphodon*, since the diameters of the internal and external portions are about equal. The characters of the posterior crest differ from

* Proceedings American Philos. Soc., 1872, p. 542.

those seen in the genus named in that the internal portion is much smaller than the external, having a small conic apex, distinct from that of the exterior portion. Its postero-external face is nearly vertical, and it diverges a little posterior to parallel with the anterior crest. The latter (the first cingulum) is elevated, and is widely separated externally from the posterior crest, to whose base it descends on the external extremity of the crown. The basal cingulum is present all round the the crown except at the base of the posterior crest, and externally. It is narrow on the inner extremity of the crown. It sends upwards a strong branch to the apex of the internal cusp. The enamel of all the molars is strongly wrinkled, but is worn smooth wherever rubbed.

Measurements.	M.
Length of superior molar series	.179
" premolar series	.085
Diameters P-m. II anteroposterior	.019
Diameters P-m. II transverse	.025
Diameters M. I anteroposterior	.029
Diameters M. I transverse	.032
Diameters M. II anteroposterior	.036
Diameters M. II transverse	.042
Diameters M. III anteroposterior	.0285
Diameters M. III transverse	.041
Diameters M. III vertical	.015

The *Metalophodon testis* differs from the *M. armatus*, in the more triangular form of its penultimate superior molar. Its form is quite different from that of the last molar, while in *M. armatus*, the two teeth resemble each other closely. The species are of about the same size.

The individual from which the above description is taken is rather aged.

DINOCERATA.

BATHYOPSIS FISSIDENS Cope.

Bulletin U. S. Geolog. Survey, Terrs., Feb. 1881, 194.

A considerable part of the dentition of the mandible of this species was found in the Big-Horn bad lands. This includes an incisor tooth, which is quite characteristic, and renders it probable that the anterior parts of the jaws differ considerably from those of other *Uintatheriidæ*. The root is sub-round. The crown resembles a good deal that of the species of *Coryphodontidæ*. It is higher than wide and has a subacute apex. One edge of the crown is convex, and the other concave. The external face is concave in both directions, and has no ridges nor cingulum. The inner face is concave longitudinally and convex transversely. The convexity is median and has a longitudinal concavity on each side of it. No internal cingulum except a trace at the base of the concave edge. The edges are obtuse even when unworn, and the enamel is obsoletely rugulose.

Measurements of incisor.		M.
Diameters of crown	anteroposterior	.012
	transverse	.020
	vertical	.020
Diameters of root	anteroposterior	.012
	transverse	.014

This incisor is very different from the kind seen in *Loxolophodon*. Mr. Osborne has shown that genus to have these teeth with compressed two-lobed crowns, a type unknown elsewhere among *Mammalia*.*

PERISSODACTYLA.

In a paper on the "homologies and origin of the molar teeth of the Mammalia Educabilia," published in March, 1874,† I ventured the generalization that the primitive types of the Ungulata would be discovered to be characterized by the possession of five-toed plantigrade feet, and tubercular teeth. No Perissodactyle or Artiodactyle mammal was known at that time to possess such feet, nor was any Perissodactyle known to possess tubercular teeth. Shortly after advancing the above hypothesis, I discovered the foot structure of *Coryphodon*, which is five-toed and plantigrade, but the teeth are not of the tubercular type. For this and allied genera, I defined a new order, the *Amblypoda*. and I have published the confident anticipation that genera would be discovered which should possess tubercular (bunodont) teeth. This prediction has not yet been realized. I now, however, record a discovery, which goes far towards satisfying the generalization first mentioned, and indicates that the realization of the prophecy respecting the *Amblypoda*, is only a question of time.

In 1873,‖ I described from teeth alone, a genus under the name of *Phenacodus*, and although a good many specimens of the dentition have come into my possession since that date, I have never been able to assign the genus its true position in the mammalian class. The teeth resemble those of suilline Ungulates, but I have never had sufficient evidence to permit its reference to that group. Allied genera recently discovered by me, have been stated to have a hog-like dentition, but that their position could not be determined until the structure of the feet shall have been ascertained.§

In his recent explorations in the Wasatch Eocene of Wyoming, Mr. J. L. Wortman was fortunate enough to discover nearly entire skeletons of *Phenacodus primævus*, and *P. vortmani*, which present all the characters essential to a full determination of the place of *Phenacodus* in the system. The unexpected result is, that this genus must be referred to the order *Perissodactyla*, and that with its allies, it must form a special division of that order corresponding in the tubercular characters of its teeth with the

* A Memoir on *Loxolophodon* and *Uintatherium*. By H. Osborne.

† Journal of the Academy of Natural Sciences, Philadelphia.

‖ Palæontological Bulletin No. 17, Oct., 1873, p. 3; also, Report G. M. Wheeler, U. S. Engineers Expl. W. 100 Mer., iv, p. 174—1877.

§ Proceedings Amer. Philos. Society, 1881, p. 495.

bunodont or suilline division of the *Artiodactyla*. In this character, however, there is a closer gradation than in the case of the *Artiodactyla*, and it would scarcely be necessary to create such a group on that character alone. But the genus differs further from the *Perissodactyla* and approaches the *Proboscidia*, in the fact that the astragalus articulates with the navicular only, and by a universally convex surface, as in the Carnivora.

The astragalus resembles that of the latter order very closely, and differs from that of *Hyracotherium* and the nearest forms among the *Perissodactyla*. *Phenacodus* has moreover five well developed toes on all the feet, and was probably not entirely plantigrade. The cast of the brain case shows that the cerebral hemispheres were quite small and nearly smooth, and that the very large cerebellum and olfactory lobes were entirely uncovered by them. The bones of the two carpal rows alternate with each other, and there is a large third trochanter of the femur. The cervical vertebræ are opisthocœlous.

This group is then the ancestral type of the known *Perissodactyla*, that is of the horses, tapirs and rhinoceroses, and of the numerous extinc forms. Its systematic position may be schematically represented as follows:

Order PERISSODACTYLA; ungulate; digits of unequal lengths; carpal bones alternating; a postglenoid process. Astragalus with proximal trochlea, and without distal double ginglymus.

Suborder *Diplarthra;* astragalus distally plane or concave in one direction, and uniting with both navicular and cuboid bones: a third trochanter of the femur. The known families belong here.

Suborder *Condylarthra;* astragalus convex in all directions distally, only uniting with navicular bone; a third trochanter of femur.

Family *Phenacodontidæ*. Molar teeth tubercular; the premolar teeth different from the molars; five digits on all the feet.

Genera; *Phenacodus* Cope, and very probably *Catathlæus, Anacodon* and *Protogonia* Cope, and perhaps also *Anisonchus* Cope. These genera include fifteen species, all from the lower Eocene beds. I gave a synopsis of their differential dental characters in the Proceedings of the Philosophical Society, 1881, p. 487, where I included also the genus *Mioclænus*. I omit the latter from the family at present, as I believe it to be Artiodactyle.

PHENACODUS PRIMÆVUS Cope.

Parts of a dozen individuals of this species were obtained, and one almost entire skeleton in a block of soft sandstone. This includes nearly all parts of the four extremities, as well as the skull, from which but small portions are wanting.

Species of this genus, so far as determinable from the dentition, are numerously represented in Mr. Wortman's collection. About fifty individuals are referable to eight species. These present a great range in size, and some diversities of structure. They may be distinguished as follows:

I. Last inferior molar with oval outline; heel small; anterior inner cusp simple.

Size medium; length of true molars .025; depth of ramus at M. II, .018. *P. apternus.*

II. Last inferior molar wedge-shaped, with heel prominent; anterior inner cusp simple.

Large; true molars .041; P-m. IV .014; depth of ramus at M. II, .027. *P. primævus.*

Medium; true molars .027; depth at M. II .017; last molar smaller..... *P. vortmani.*

Smaller; true molars .022; depth at M. II .013; last molar elongate;.. *P. macropternus.*

Smaller; last four molars .027; P-m. IV .007; depth at M. II .013; last molar with short heel.....*P. brachypternus.*

Smallest; true molars .017; depth at M. II .012; heel long; cusps elevated.....*P. zuniensis.*

III. Last inferior molar wedge-shaped, with prominent heel; anterior inner cusp double;

Least; last inferior molar .006; heel narrow; true molars (superior) .016. *P. laticuneus.*

Two other species have been described, the *P. sulcatus*, and *P. omnivorus* Cope. The former I suspect belongs to another genus. I am not now sure of the distinctness of the latter from *P. primævus.*

PHENACODUS HEMICONUS, sp. nov.

Represented by the posterior two superior molars of an individual intermediate in size between the *P. primævus* and *P. puercensis.* The posterior molar is peculiar in the very rudimental character of the posterior internal lobe, which is reduced to a mere wart on the cingulum. The posterior external tubercle is also rudimental, not exceeding the posterior inner in dimensions. The anterior tubercles, including the intermediate, are well developed, the internal exceeding the external. The cingulum is wide and crenate, and is only wanting on the external base of the crown. The penultimate molar does not differ so much from that of *P. primævus*, but the two internal cones are not so deeply separated at their base. The tubercles are all but little worn, and are conical in form, the external flattened on the external faces. Enamel wrinkled.

Measurements.		M.
Diameters of M. II	anteroposterior	.009
	transverse	.012
Diameters of M. III	anteroposterior	.010
	transverse	.013

The size of this species precludes the possibility of its identity with any of the other species described here.

PHENACODUS WORTMANI Cope. Bulletin U. S. Geol. Surv. Terrs. vi, 1881, p. 199. *Hyracotherium vortmani*, American Naturalist, 1880, p. 747.

Phenacodus puercensis Cope. Proceeds. Amer. Philos. Soc. 1881, p. 492.

An abundant species, represented by twelve mandibular rami in the collection, and by a nearly entire skeleton with perfect skull.

PHENACODUS APTERNUS, sp. nov.

Three rami, each of which supports the true molar teeth, indicate this species. The oval form of the posterior molar is due to the shortness of the heel, and the large size of the internal median tubercle, which projects inwards, giving a convex outline to the interior side of the crown. The external tubercles of all the true molars wear into crescents ; and the anterior inner is more robust than the posterior inner.

PHENACODUS MACROPTERNUS, sp. nov.

This species is apparently rare, being represented by only one mandibular ramus, which supports the posterior three molars, and a possible second ramus with molars iv and v. The first and second true molars are much like those of *P. vortmani*, but the third is relatively larger, and has an especially elongate heel. In *P. vortmani* the last molar is constricted, and narrower than the penultimate. In *P. macropternus* there is a weak external, and no internal cingulum. The tubercles of the last two molars are quite regularly conical, while the external pair of the first molar, wear into crescents. Smaller than the *P. vortmani*.

PHENACODUS BRACHYPTERNUS, sp. nov.

Three mandibular rami are the only specimens of this species found by Mr. Wortman in the Big-Horn region. They all display the fourth premolar, which has the characters of this genus, as distinguished from *Mioclænus*. The species is materially smaller than the *P. vortmani*, and its last inferior molar is intermediate between those of the latter and the *P. apternus*, in form. Both the internal and external intermediate tubercles are very full, and give the tooth posterior width. The posterior or fifth tubercle is large, and gives the posterior outline of the crown a trifoliate form. The posterior median tubercles of the M. II and I, are well marked. The molars gradually increase in size forwards, and the fourth premolar is longer than any of them, and rather narrow. The heel of the P-m. III is short and wide. On the true molars a weak external cingulum. Enamel slightly wrinkled.

PHENACODUS ZUNIENSIS Cope. Proceeds. Amer. Philosoph. Society, 1881, p. 462.

Mr. Wortman obtained eleven mandibular rami of this species, in only one of which are the premolars preserved. Excepting the *P. laticuneus*, this is the smallest species of the genus. The molars have much the appearance of those of the Mesodont genus *Hyopsodus*, but may be distinguished by the size of the posterior median tubercle. The second true molar is the widest tooth, and the last molar is rather elongate, and its cusps are not exactly opposite to each other. The cusps of the molars

are more elevated than in the other species, and those of the external side all have a distinctly crescentic section. The anterior inner cusp is narrow and simple. There is no cingulum of any kind.

This species was originally described from New Mexican specimens.

PHENACODUS LATICUNEUS, sp. nov.

This is the least species, and is represented by six superior molars and the last inferior molar in a fragment of the lower jaw. The latter tooth exhibits peculiar characters already mentioned. The superior molars differ from those known to belong to the *P. primævus* and *P. puercensis* in having a vertical fissure of the inner side which separates the bases of the two internal tubercles. This gives them some resemblance to the superior molars of the species of *Anisonchus*, but the important difference remains in the separation of the anterior inner tubercle from the intermediate tubercles. The three are confluent into a V in the genus last mentioned.

The external cusps of the superior molars are rather acute, and lenticular in section, their external sides forming a convex rib. There is no rib between the external sides. There is a strong anterior cingulum, which terminates externally in a low angular cusp. There is no cingulum on any other part of the crown. The second, third and fourth premolars have two external cusps, and much resemble the corresponding teeth in *Hyracotherium*. The second is longer than wide, and has an internal ledge; the third is as wide as long and has a wide internal ledge; the fourth is wider than long and has an internal, and two intermediate cusps, and an anterior and posterior cingulum. They all have a weak external cingulum, of which a trace exists in the true molars.

The last inferior molar has a double anterior inner cusp as in some *Mesodonta*, and the external anterior cusp is robust. All the cusps are conical and with round section, and their bases are close together. The outline of the base of the crown is almost an isosceles triangle with rather wide base in front.

Measurements.	M.
Length of last six superior molars	.0350
" true molars	.0160
Diameters of M. II { anteroposterior	.0055
Diameters of M. II { transverse	.0080
Long diameter base of P-m. II	.0050
Diameters P-m. III { anteroposterior	.0060
Diameters P-m. III { transverse	.0060

ANACODON URSIDENS, gen. et sp. nov.

Char. gen. Known only from mandibles supporting molar teeth. Probably family *Phenacodontidæ*. Last inferior molar with heel. Crowns of molars without distinct cusps, but with a superior surface consisting of two low transverse ridges separated by a shallow valley. Unworn grinding surface with shallow wrinkles. Perhaps only three premolars.

Char. specif. Broken mandibular rami of two individuals constitute the basis of my knowledge of this species. It is of the size of the *Phenacodus primævus*. The last inferior molar is wedge-shaped with the very obtuse apex posterior. It displays two slight transverse elevations anteriorly which represent the usual cusps. Grinding surface generally nearly flat. The posterior half of the crown of the penultimate molar is flat, and is separated from the anterior half by a transverse groove. Its surface is marked by shallow branching grooves.

The molar preceding this one in the broken specimen is probably the first. It is possible from its slightly worn condition that it is the fourth premolar, but the form is that of a true molar. The surface of the crown is marked by shallow grooves not very closely placed. The three premolar teeth in advance of this tooth are broken off. Their bases are narrow. There are no basal cingula on the molars.

Measurements.	M.
Length of posterior true molars	.033
Diameters of M. III { anteroposterior	.015
Diameters of M. III { transverse	.010
Diameters of M. ? I { anteroposterior	.015
Diameters of M. ? I { transverse	.011
Depth of ramus at M. II	.030

The characters of the teeth of this species are something like that of some of the *Palæochœri* of the Miocene, and resemble more those seen in some of the bears.

Oligotomus osbornianus, sp. nov.

Char. gen. Dental formula; I. ?, C. ?, P-m. ? $\frac{4}{4}$; M. $\frac{3}{3}$. External faces of external lobes of superior molars separated by a ridge; anterior external cusp of cingulum little developed. Premolars of superior series different from true molars, with only one internal lobe. Fourth inferior premolar similar to the true molars. Cusps of inferior molars connected by diagonal ridges forming Vs. A diastema in front of the second premolar.

This genus is a good deal like *Lambdotherium*, so far as known. Its superior molars are much like those of *Aeoëssus*, and their intermediate and internal tubercles are those of *Hyracotherium*.

The two or three species known to me are of small size.

Char. spec. The true molars of both maxillary bones, with the fourth premolar of one side are preserved more or less perfectly, with four inferior molars on two fragments of the lower jaw.

The external tubercles of the superior molars are nearly erect, and have a lenticular section. The rib which separates their external faces is prominent, and terminates in a free apex. The base of each face is marked by a strong cingulum, but the posterior one is very short. There is a strong anterior basal cingulum, but no posterior or internal one. The anterior inner tubercle is larger than the posterior. The intermediate tubercles are

sub-round, and are anterior to the transverse line of the interior ones. They do not join the latter excepting after very considerable wear. The external anterior cingular cusp is rather more prominent on the first than on the second true molar. The fourth superior premolar has a well marked external anterior cingular cusp, which is, however, low; and there is no ridge dividing the external faces of the external cusps. The single inner cusp is connected with the two external by two ridges, which diverge as they extend outwards. The anterior supports a tubercle close within the anterior external. There are strong anterior and posterior basal cingula and weak external and internal ones.

The third inferior premolar has a compressed ridge on the heel. The fourth premolar is like a true molar, with the anterior inner cusp well developed and elevated, and connected with the anterior and posterior external by oblique ridges. The inner posterior cusp is less conic in form than in the true molars, and the entire crown is somewhat contracted anteriorly. The true molars are characterized by the presence of a small median tubercle on the posterior border. There is a low external basal cingulum, which is wanting opposite the posterior cusp. Enamel generally smooth.

Measurements.	M.
Length of superior true molar series	.0210
Diameters of superior M. II { anteroposterior	.0080
Diameters of superior M. II { transverse	.0097
Diameters of P-m. IV { anteroposterior	.0085
Diameters of P-m. IV { transverse	.0085
Length from inferior P-m. III to M. II inclusive	.0290
Diameters of P-m. IV { anteroposterior	.0080
Diameters of P-m. IV { transverse	.0050
Diameters of inferior M. II { anteroposterior	.0075
Diameters of inferior M. II { transverse	.0060
Depth of ramus between P-m. III and P-m. IV	.0150

As compared with the *O. cinctus*,* this species differs in its superior dimensions. The anterior inner cusp of the inferior molars is probably single, though the slightly worn condition of those teeth renders this point a little uncertain. In *O. cinctus* some of them at least are double.

This species was, to judge from the size of its teeth, about the size of a red-fox. The specimens of it above described were found by Mr. J. L. Wortman in the bad lands of the Big-Horn river, Wyoming. It is dedicated to my friend, Henry L. Osborne, of Princeton College, New Jersey.

Systemodon tapirinus Cope. American Naturalist, 1881, p. 1018.

Hyracotherium tapirinum Cope. Systematic Catalogue of the Eocene Vertebrata of New Mexico, 1875, p. 20. Report U. S. Geol. Surv. W. of 100th mer. Capt. G. M. Wheeler, iv. ii. p. 263. Pl. lxvi. figs. 12–16.

This species was abundant in Wyoming during the Wasatch epoch, jaws and teeth of more than twenty individuals having been brought by

* Annual Rept. U. S. Geol. Survey Terrs. 1872, p. 607.

Mr. Wortman from the Big-Horn. From these I learn that the dental system is different from that characterizing the species of *Hyracotherium*. There is no diastema posterior to the superior canine, while in the latter genus there are two. Anterior to the canine there is a considerable one in the *Hyracotherium*. This part is not preserved in any of the specimens of *S. tapirinum*. The characters mentioned have induced me to separate the latter as type of a distinct genus, *Systemodon*. An examination of the figures and descriptions given by Dr. Lemoine of his *Pachynolophus gaudryi* found by him in the neighborhood of Reims, shows that it belongs to the genus *Hyracotherium*. It is therefore distinct from either of the species of *Systemodon*, and is to be compared with the *H. craspedotum* of the Wind River country, with which it agrees in size.

SYSTEMODON SEMIHIANS, sp. nov.

This species was also abundant in the Big-Horn region, jaws and teeth of sixteen individuals having been obtained. Its dimensions are a little smaller than those of the *S. tapirinus*, especially as to the premolar teeth. There is also a short postcanine diastema, which is not seen in the *S. tapirinus*.

The proportions of the maxillary series are represented by a left maxillary and premaxillary bone, with all the teeth in place, but the crowns lost from the first premolar anteriorly. The crowns of the true molars are somewhat worn, so I confine the description of these to the premolars. The third and fourth have considerable transverse extent, the latter being wider than long. The second has scarcely any internal tubercle, but only a low postero-internal heel. The internal tubercle of this tooth is large in *S. tapirinus*. The crown has two cusps, the posterior lower. The last two premolars have two external cusps close together. They have also an anterior external cingular lobe, as in the true molars. There is a posterior external basal lobe in the third premolar, but none or a rudiment on the fourth. No internal cingulum on the premolars. The superior true molars, although worn, show a prominent anterior external basal lobe, and no complete internal cingulum The base of the crown of the first premolar is narrow antero-posteriorly, and it has two roots as in *S. tapirinus*. It is in close contact with the second premolar, and is separated from the base of the canine by a space a little less than its own anteroposterior diameter, and less than the diameter of the canine. The base of the crown of the latter shows that it is not a large tooth, and has a wide lenticular section. The base of the external incisor is rather large, and is compressed.

Measurements of superior teeth..		M.
Total length of superior series		.0720
" " " molar "		.0310
" " " premolar "		.0250
Diameters base of canine	anteroposterior	.0055
	transverse	.0040

Measurements of superior teeth.		M.
Length of base of P-m. I		.0040
Diameters P-m. III	anteroposterior	.0070
	transverse	.0078
Diameters P-m. IV	anteroposterior	.0070
	transverse	.0090
Diameters M. III	anteroposterior	.0100
	transverse	.0125

Some superior molars in better condition than those last described, exhibit the following characters. The intermediate tubercles are fused with the internal, forming a continuous cross crest, but their apices are distinguishable. The external cusps are subconical and are well separated. The anterior and posterior cingula are strong, the external is weaker, and it is wanting from the posterior part of the internal base of the crown.

A portion of a mandibular ramus, supporting six molars, presents the following characters. The teeth are a little smaller than those of *S. tapirinus*, the reduction being especially visible in the premolars. The cones of the crowns are more distinctly separated by notches than in that species, and are quite distinctly conic. The anterior ledge of the true molars is distinct, and there is a median posterior tubercle of the first two, which is represented by the wide crenate-edged heel of the third true molar. The anterior-internal cusps of the last two molars is double or bilobed ; that of the first is last. The anterior cones of the fourth premolar are subequal, and the posterior external cone is elevated. There is a trace of the posterior internal. There is also an anterior ledge. The heel of the third premolar rises to a median blade and posterior cusp. The anterior cusp is elevated and compressed, and supports a small internal lateral cusp. The base of the crown of the third premolar is elongate. All the teeth are rather compressed, and there is only a trace of an external cingulum.

The ramus is compressed and moderately deep. The dental foramen is large, and its superior border is on a level with the posterior base of the crown of the third true molar. Its inferior base is in line with the base of the crown of the second true molar.

Measurements of mandible..		M.
Length of last six molars		.0530
" true molars		.0310
Diameters third premolar	anteroposterior	.0065
	transverse	.0040
	vertical	.0052
Diameters second true molar	anteroposterior	.0092
	transverse	.0060
	vertical	.0062
Diameters third true molars	anteroposterior	.0120
	transverse	.0060
Depth of ramus at P-m. III		.0170
Depth of ramus at front of M. III		.0220

The nearest ally of this species outside of the genus *Systemodon* is probably the *Hyracotherium craspedotum* Cope. This species was brought from the Wind River bad lands, and does not occur in the Big-Horn collection. It is about the size of the *S. semihians*, but is a true *Hyracotherium*, with a diastema behind the first premolar. The strong cingulum which characterizes it is not found in the *S. semihians*, and the inferior molars are wider and more robust.

HYRACOTHERIUM CRASPEDOTUM Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, p. 199. American Naturalist, 1880, 747.

The dentition of this species is in its dimensions and proportions intermediate between the two species of *Systemodon*. Its three premolars equal four of those of the *S. semihians*, while the molars of the two species are about equal.

A specimen having the proportions of the *H. craspedotum* was found by Mr. Wortman on the Big-Horn, but unfortunately it does not exhibit the characteristic cingula of the two dental series. The second superior premolar, like that of *Systemodon semihians* has no internal tubercle. It is not certain whether there is any diastema posterior to the first superior premolar. I therefore cannot yet ascertain whether this specimen represents an undescribed species of *Systemodon* or *Hyracotherium*, or a strong variety of the *H. craspedotum*. The accompanying inferior true molars are intermediate in size between those of the latter species and the *H. vasacciense*.

HYRACOTHERIUM VASACCIENSE Cope.

This species differs from the *H. venticolum* in its deep mandibular ramus. A single specimen from the Big-Horn presents the same proportions. The posterior inferior molar is rather short.

HYRACOTHERIUM VENTICOLUM Cope.

Bulletin U. S. Geol. Survey, Terrs., 1881, 198.

Fifteen individuals of this species are included in the collections.

HYRACOTHERIUM ANGUSTIDENS Cope.

This was a very abundant species. Mr. Wortman's collection contains jaws and teeth of twenty individuals sufficiently well preserved for identification, and a large number of other pieces of jaws, etc., which may be reasonably inferred to belong here.

In my report on the Wind River collection*, I noticed three varieties of this species, which differ in the depths of the ramus at the line of junction of the fourth and fifth molars. The numbers are 12, 14, and 15.5 mm. respectively. The lengths of the first true molar also vary from 7 to 6.5 and 7.5 mm. respectively. The last true molar measures in all 10.0 mm. The majority of the Big-Horn specimens agree with the second variety, but two others occur, one a little smaller, and the other a little larger than the average. The former measures ; length of last molar .0090 ; of

* Bulletin U. S. Geol. Survey Terrs. VI, 1881, p. 198.

first molar .0067; depth of ramus at M. I, .0120. The dimensions of the larger variety are: length of M. iii, .110; of M. i, .0067; depth ramus .0165. The New Mexican forms originally described, exhibit combinations of several of these measurements.

PACHYNOLOPHUS VENTORUM Cope.

Bulletin U. S. Geol. Surv. Terrs., 1881, p. 197. American Naturalist, 1880, p. 747.

One mandibular ramus.

PACHYNOLOPHUS POSTICUS, sp. nov.

Both rami of a mandible represent this large species. They are somewhat injured, and the crowns of five of the molars only can be distinctly seen. The latter display the characters seen in the *P. ventorum* and other species of the genus. The transverse crests are well characterized, and the valley between them uninterrupted. They are closed at the inner extremity by a low ridge nearly at right-angles with the cross crest posterior to them, as in the species of *Rhinocerus*. The anterior of these bounds an anterior ledge, which is quite large on the last true molar. The latter has a rather narrow, but prominent heel, which rises posteriorly. The fourth premolar has an anterior ledge, and wide heel with a diagonal crest which is median in front. The third premolar is similar, but smaller. The only cingulum is seen on the anterior part of the external side of all the true molars.

Measurements.	M.
Length of crowns of posterior six molars	.0700
" " true molars	.0440
Diameters P-m. iv { anteroposterior	.0095
Diameters P-m. iv { transverse	.0070
Diameters M. ii { anteroposterior	.0130
Diameters M. ii { transverse	.0095
Diameters M. iii { anteroposterior	.0180
Diameters M. iii { transverse anteriorly	.0092
Depth ramus at P-m. ii	.0280
" " M. ii	.0310

ARTIODACTYLA.

MIOCLÆNUS BRACHYSTOMUS, sp. nov.

Char. gen. The typical specimen of this species is represented by all the molar dentition of both jaws excepting the anterior three superior premolars. It also includes pelvis, femur, the distal parts of the tibia and fibula, the entire tarsus and the proximal portion of the metatarsus.

The dental characters conform precisely to those of the other species of *Mioclænus*. There is but one internal cusp of the superior true molars, and the intermediate tubercles are present. The fourth premolar has one external and one internal lobe. The inferior premolars have simple crowns without interior cusps or tubercles.

The characters of the tarsus are of much interest, and demonstrate that *Mioclænus* is the oldest type of artiodactyle yet discovered, and that it is not altogether primitive in some of its characters. Members of this order have been found by Cuvier in the upper Eocene (*Dichobune, Anoplotherium,* etc.), but none have been determined as yet from the Suessonian of America. A species represented by teeth from the Siderolithic beds of Switzerland have been referred to *Dichobune* (*C. campichii* Pict.); but dental characters alone are not sufficient to distinguish that genus from *Phenacodontidæ**. Dr. Lemoine found astragali of a small Artiodactyle in the Suessonian of Reims, and has referred them to his supposed Suilline *Lophiochœrus peroni.* I have reported an astragalus from the Wind River formation of Wyoming Territory, which is almost exactly similar to those found by Lemoine. The specimen now described, enables me to characterize with some degree of completeness this interesting form, which precedes in time all the known American *Artiodactyla.*

The characters of the tarsus are typically those of the order *Artiodactyla.* The astragalus exhibits a distal trochlea which is continuous with the sustentacular facet, and which articulates with both cuboid and navicular. The distal portion of the fibula is free from the tibia, and its shaft becomes very slender. It is possible that a more perfect specimen would display it as continuous. Its distal extremity articulates with the ascending tuberosity of the calcaneum. The cuboid facet of the latter is narrow. The cuboid and navicular bones are distinct from each other and from the cuneiforms. The mesocuneiform is shorter than the ectocuneiform, and *is coössified with it.* There are probably four metatarsals. The median pair are distinct, but appressed, their section together, sub-circular. The ateral metatarsals are slender, the external one is wanting, but its facet on the cuboid bone is very small.

These characters are in general similar to those of the genus *Dichobune,* but Cuvier† does not state whether the cuneiforms are coössified in that genus or not. They are united in Anoplotherium.‡ *Mioclænus* differs from *Dichobune* in the presence of but one internal tubercle of the superior molars, and in the single external tubercle of the superior premolars. Both genera are referable to a family to be distinguished from the *Anoplotheriidæ* by the presence of the external digits. This has been already named by Gill the *Dichobunidæ.*

Char. specif. The bones are about two thirds the size of those of the Javan musk deer (*Tragulus javanicus*). The transverse extent of the superior true molars is greater than the anteroposterior. The composition of the last molar is like that of the others. The external tubercles are lenticular in section and the emargination which separates them is apparent on the external face of the crown. The intermediate tubercles are small, and are entirely distinct from the large external tubercle. There

* See American Naturalist, 1881, December.

† Ossemens Fossiles, v, p. 183.

‡ Gaudry Enchainements d. Regne Animal, p. 147.

is a distinct cingulum which is only wanting from the inner base of the crown. The fourth superior premolar has a trilobate outline of the base of the crown, the base of the inner lobe being contracted where it joins the external part of the crown. The internal tubercle is conic, with a prolongation outwards and forwards. Intermediate tubercle not distinct. External, anterior, and posterior cingula.

In the inferior true molars the external tubercles wear into crescents, The crowns increase in size posteriorly, which is the reverse of the order of enlargement in some of the other species of the genus. The fifth tubercle of the last molar is rather small, but is well distinguished from the other cusps. The internal median cusp is small, the external median large. The premolars are not so much larger than the true molars in this as in the typical species of the genus. The second and third are more elongate on the base than the fourth. The latter is also less compressed than those that precede it. It has a short wide heel, and a small anterior basal tubercle. In the second and third premolars the posterior edge of the principal cusp is sharp, and descends gradually to the posterior base of the crown. Both have small acute anterior basal tubercles. The first inferior premolar is one-rooted, and has a simple crown directed somewhat forwards. It is separated from the second by a short space. The teeth anterior to this point are lost.

Measurements.	M.
Length posterior four superior molars	.0182
Diameters P-m. IV { anteroposterior	.0040
Diameters P-m. IV { transverse	.0042
Diameters M. II { anteroposterior	.0043
Diameters M. II { transverse	.0060
Diameters M. III { anteroposterior	.0040
Diameters M. III { transverse	.0060
Length of inferior molars	.0330
" " premolars	.0192
" " P-m. III	.0055
" " P-m. IV	.0045
Diameters M. I. { anteroposterior	.0040
Diameters M. I. { transverse	.0033
Diameters M. III { anteroposterior	.0052
Diameters M. III { transverse	.0040
Depth of ramus at P-m. I	.0047
" " M. II	.0090
Length of astragalus	.0102
Width of trochlea behind	.0048
Diameters of cuboid { length	.0070
Diameters of cuboid { width of middle	.0040

MIOCLÆNUS ETSAGICUS, sp. nov.

This, the largest species of the genus, is represented by the two rami of

a mandible of an adult animal in good preservation. In their robust character the premolar teeth resemble those of the *M. turgidus*, but are not relatively so large, nor is the last true molar relatively so small, as in that species. The heel of the third premolar is obsolete, and that of the fourth is a wide cingulum. Neither exhibit an anterior basal tubercle, and in both the principal cusp is stout. The true molars widen posteriorly to the anterior part of the last molar. The latter contracts rapidly to a narrow heel. The tubercles are all subconic, and the median ones of the last molar are small. There are no cingula, and the enamel is smooth.

The ramus is not robust, and is of moderate depth. Its inferior border rises below the middle of the last molar tooth, and posteriorly. There is a "mental" foramen below the contact of the fourth premolor and first true molar.

Measurements.	M.
Length of bases of six posterior molars	.047
" " three premolars	.024
" " P-m. II	.009
" " P-m. IV	.008
" " P-m. IV	.005
Diameters basis of M. II { anteroposterior	.0075
{ transverse	.0070
Diameter basis M. III { anteroposterior	.0084
{ transverse	.0070
Depth of ramus at P-m. II	.0080
" " M. II	.0140

This species is named from the Crow Indian name of the Big-Horn river, *Etsagie*.

Concluding Remarks.

The paleontologist who has examined the preceeding list, will readily perceive that it represents fully the Wasatach fauna, with little admixture of earlier or later forms. The only genus which belongs to the Bridger or middle Eocene, which occurs in the Big-Horn basin, is *Pappichthys*, The characteristic Bridger genera *Hyrachyus, Palæosyops, Uintatherium*, and the *Tillodonta*, are absent, and their place is taken by *Phenacodus, Hyracotherium, Coryphodon* and *Tæniodonta*, as in New Mexico. Several genera are, as elsewhere, common to the two horizons, and two species cannot be distinguished in the parts preserved. Such as *Hyopsodus paulus* and *H. vicarius*. A closer comparison may be made with the Wind-River group, on which I published a report in the Bulletin of the U. S. Geological Survey of the Territories.* The following genera found in that formation have not been obtained from the Big-Horn. *Protopsalis, Lambdotherium, Palæosyops, Hyrachyus.*† Genera of the Big-Horn not obtained from the Wind-River: *Cynodontomys, Anaptomorphus; Mesonyx,*

*1881, Feb. p. 201.

† Since making my report on the Wind-River fauna, I have found the anterior part of the lower jaw of a species of this genus.

Deltatherium, Oxyæna; Manteodon, Ectacodon, Metalophodon; Anacodon, Oligotomus, Systemodon; Mioclænus. Three of these genera have been found in the Bridger, and five have been obtained in the lower Eocene of New Mexico. Five of the genera are new to science.

An especial feature of the Big-Horn collection, as distinguishing it from those brought from other regions of the Wasatch formation, is the presence of numerous species of *Phenacodus*, and of new and rare species and genera of *Coryphodontidæ*.

II. The Fauna of the Catathlæus Beds or Lowest Eocene of New Mexico.

A number of new species and genera from this horizon were described in my Paleontological Bulletin No. 33. The present paper adds a few to this list. Up to the present time no species of *Coryphodon*, and but few specimens of *Hyracotherium* have been discovered in this formation, thus exhibiting a marked contrast to the Wasatch beds. The predominant genus is *Catathlæus*, which is represented by one very abundant species. The genera of *Creodonta* are mostly distinct from those of the Wasatch. The Diplarthrous Perissodactyla, so numerous in the Wasatch, are rare here. The genus which is well represented in both formations, is *Phenacodus;* and *Mioclænus* occurs in both. *Mesodonta* are much less numerous than in the Wasatch, and *Amblypoda* have not yet certainly been found.

This is the only Tertiary formation where the Laramie genus *Champsosaurus* occurs. It is represented by three species.

Psittacotherium multifragum Cope.

American Naturalist, 1882, p. 156, Jan. 25th.

An interesting new form of this sub-order has been found in the *Catathlæus* beds (probably the Puerco formation) of New Mexico. It differs widely from the two genera hitherto known, *Anchippodus* and *Tillotherium*. Owing to the absence of the superior dental series, it is not possible to be sure which is the canine. The inferior dental formula may be therefore written, I. 2; C. 1; P-m. 3; M. 3; or I. 3; C. 0; P-m. 3; M. 3; or I. 3; C. 1; P-m. 2; M. 3. The first and second incisors are large and rodent-like, growing from persistent pulps; the second are the larger. The third, or canines, are small and probably not gliriform. There is no diastema. The first premolar (or canine) has a compressed crown with two cusps placed transversely to the jaw axis, and has a complete enamel sheath, and probably two roots. The succeeding tooth is also transverse, and is two-rooted, judging from the alveolus. The first and second true molars are rooted, and the crown consists of two transverse separated crests, each partially divided into two tubercles. On wearing, the grinding surface of each assumes the form of a letter B with the convexities anterior. The last inferior molar is injured. The rami are short, and the symphysis deep and recurved.

Specific characters. The base of the coronoid process is opposite the junction of the second and third true molars. The ramus is deep and mod-

erately stout. The enamel of the first incisor does not extend below the alveolar border, at the internal and external faces, and does not reach it at the sides. It has a few wrinkles on the anterior face. The anterior enamel face of the second incisor is thrown into shallow longitudinal grooves with more or less numerous irregularities from the low dividing ridges. There is a deeper groove on each side of the tooth, and there are about a dozen ridges between these on the anterior face. Both cusps of the first premolar are conic, and the external is the larger. The second true molar is a little smaller than the first. The enamel of the premolars and molars is smooth, and there are no cingula.

Probable length of dental series, .0750; diameters of I. 1: anteroposterior, .0120, transverse, .0066; diameters I. 2: anteroposterior, .0160, transverse, .0115; diameters P-m. 1: anteroposterior, .0072; transverse, .0130; diameters of M. ii. anteroposterior, .0090, transverse, .0090. Length of true molars, .0038; depth of ramus at M. ii, .0360.

The short deep jaws of this animal must have given it a very peculiar appearance, not unlike that of a parrot in outline.

PSITTACOTHERIUM ASPASIÆ, sp. nov.

Represented by two mandibular rami of two individuals, one adult, the other nearly so, but with the last inferior molar not fully protruded. The latter specimen must be used for description, as it presents two molar teeth, while the other specimen has lost them.

The most obvious difference from the *P. multifragum* is its inferior size, which can be readily perceived from the measurements given. The posterior crest of the molars appears to have less transverse extent than in the larger species. This crest in the last inferior molar has a curved crenate edge, with a small conic tubercle at its external extremity. The anterior crest consists of two conic tubercles, whose apices converge, but whose bases are closely appressed, and only distinguished by a superficial fissure. The valley between the crests is uninterrupted. The preceding molar is larger, and its posterior crest is like that of the lost molar. The apex of the anterior crest is broken off.

The ramus deepens rapidly forwards, and contains the enormous alveolus for the incisors. The coronoid process leaves the alveolar border at the line separating the last two molars, or, in the smaller specimen, a little anterior to this point, and is quite prominent. The masseteric fossa is well marked, but shallows gradually anteriorly and inferiorly.

Measurements.

No. 1.	M.
Depth of ramus at penultimate molar	.027
Width of last molar anteriorly	.008
Length of crown of do	.009
No. 2.	
Depth of ramus of penultimate molar	.029
" " at P-m. ii	.043
Length of five consecutive alveoli	.047

From the Puerco bed of N. W. New Mexico.

TRITODON HEILPRINIANUS, sp. nov.

This species may be readily recognized as smaller than the *T. quivirensis*, and as having the anterior inner cusp of the inferior true molar of larger proportions than in the corresponding teeth of the latter species. It is only represented in my collection by a portion of a lower jaw, which supports only one well preserved molar. As the fourth premolar is not present, it is not positively ascertained that the species does not belong to *Ictops*.

The anterior cusp is very low, and is nearer the inside than the middle of the anterior border. The principal anterior cusps are opposite, and the external is a little the larger. The heel is larger than the basis of the anterior cusps, and has convex borders. Its internal border supports three tubercles, and the external border rises into a cutting lobe with lenticular section. Enamel smooth. No cingula, but the external base is injured.

Measurements.			M.
Diameters of inferior molar	vertical	of cusps	.0070
		of heel	.0052
	anteroposterior		.0110
	transverse		.0065

Puerco beds of New Mexico.

Dedicated to my friend, Professer Angelo Heilprin, of Philadelphia.

SARCOTHRAUSTES ANTIQUUS, gen. et sp. nov.

Char. gen. We have in evidence of the characters of this genus, the last two superior molars, the last one lacking the crown; and parts of both mandibular rami, which exhibit teeth as far posteriorly as the first true molar inclusive; all belonging to one individual. A part of a skeleton of a second individual, which includes a fragment of lower jaw, belongs probably to this species.

Sarcothraustes resembles both *Amblyctonus* and *Mesonyx*, but it is probably to the latter genus that it is allied. The last superior molar is transverse, much as in *Oxyæna*. The crown of the penultimate is subtriangular and transverse. It has two external subconic cusps and a single internal lobe, whose section on wearing is a V, each branch of the face extending to the base of the corresponding external tubercle. There are three small inferior incisors, and a large canine. There are probably only three inferior premolars, the first one-rooted. The crown of the second has no heel. The crown of the third has a short wide heel. The crown of the first true molar consists of an anterior elevated cone and a posterior heel. The latter is wide, having a posterior transverse, as well as a longitudinal median keel. The fragments of the supposed second individual include two large glenoid cavities with strong preglenoid crests, as in *Mesonyx*.

As compared with *Mesonyx*, this genus differs in the V-shaped crest of the penultimate superior molar; in *Mesonyx* it is represented by a simple cone. The last superior molar of *Mesonyx* is triangular and not transverse, but the composition of the crown of that tooth in *Sarcothraustes* must be

known before the value of this character can be ascertained. If the view that *Sarcothraustes* has but three inferior premolars be correct, this character distinguishes it from *Mesonyx*, as do also the transversely expanded heels of the molars. The family *Mesonychidæ* may be for the present regarded as embracing the three genera of *Sarcothraustes, Mesonyx* and *Dissacus.**

Char. Specif. The penultimate superior molar has a strong posterior cingulum which commences within the line of the internal bases of the external cusps, and rises into considerable importance behind the internal cusp. There is also an anterior cingulum which does not rise internally, and which is continuous with a strong external basal cingulum. The latter passes round the posterior base of the posterior cone, and runs into the posterior branch of the internal V. The posterior cone is smaller than the anterior cone, and its apex is well separated from the latter. The appearance of this tooth is something like that of a carnivorous marsupial.

The symphysis mandibuli slopes obliquely forwards, and is united by coarse suture. The ramus is stout and deep, as compared with the size of the molar teeth. The roots of the teeth are relatively large, especially those of the first two premolars. The crown of the canine is lost. The first premolar points forwards, nearly parallel with the canine, and divergent from the second premolar. The crown of the second premolar is small and subconic, and has a rudimental heel, and no anterior basal tubercle. The first true molar resembles considerably that of *Mesonyx*. There is a small anterior basal tubercle on the inner side of the principal cusp. The expansion of the heel is transverse only, there being no longitudinal lateral edges or tubercles. The enamel is obsoletely, rather coarsely wrinkled. There are two rather large mental foramina; the posterior below the anterior root of the first true molar, and the anterior below the posterior root of the second premolar.

Measurements.		M.
Diameters of superior M. ii	anteroposterior externally	.015
	transverse	.024
Anteroposterior diameter of base of M. iii		.0095
Anteroposterior diameter base of crown of inferior canine		.020
Length of bases of three inferior premolars		.038
Diameters inferior M. i.	anteroposterior	.019
	transverse	.0095
	vertical	.0110
Depth of ramus at P-m. iii		.0520
Width " "		.022

* American Naturalist, Dec., 1881.

CHAMPSOSAURUS PUERCENSIS, sp. nov.

I have already announced the discovery * of this Laramie genus in the Puerco beds of New Mexico, and described a species, *C. australis*, from that region. I now introduce two additional species from the same horizon. One of these is represented by a number of fragments which include three dorsal and four caudal vertebræ of apparently one individual. They represent an animal of larger size than any of those heretofore referred to *Champsosaurus*, excepting the *C. vaccinsulensis*. In all of the vertebræ the neural arch is more or less coössified with the centrum, and the animal had probably reached its full size.

One of the dorsal *centra* is split vertically and longitudinally, and shows the structure already figured by Leidy in the *Ischyrosaurus antiquus* † Leidy. The surface exposed displays two diagonal lines of fissure crossing each other at right angles. They indicate clearly the mode of origin of this amphiplatyan type of centrum. The centrum is first deeply amphicœlous as in the Theromorphous reptiles of the Permian. The conical cavities are filled by the ossification of the remaining portions of the notochord, forming a conical body which always remains distinct from the remainder of the centrum.

The articular faces of the dorsal centra are a little wider than deep, and the depth about equals the length of the body. They are not nearly so depressed as those of *C. australis*, and their outline is different. This is wider above and narrows below ; in both *C. australis* and *C. saponensis* the inferior outline is part of a circle. None of the dorsals preserved are keeled below. There is a fossa below the diapophysis which has a subvertical posterior boundary. The general surface (somewhat worn) does not display wrinkles near the articular faces. An anterior dorsal has a short compressed diapophysis with a narrow figure 8 articular surface, and its superior border is in line with the roof of the neural canal. The anterior caudals have subround articular faces ; the posterior are more oval and the bodies compressed. With greater compression, the length increases.

Measurements.		M.
Diameters of an anterior dorsal	anteroposterior	.025
	vertical	.025
	transverse	.030
Height of costal facet of do		.021
Diameters neural canal do.	vertical	.007
	transverse	.009
Diameters anterior caudal	anteroposterior	.024
	vertical	.021
	transverse	.021
Diameters posterior caudals	anteroposterior	.025
	vertical	.018
	transverse	.018

* American Naturalist, 1881. p. 669.

† Transac. Amer. Philos. Soc. 1860.

The typical specimen was found by Wm. Baldwin near the Puerco river, west of the Nacimiento mountain, New Mexico, in the typical locality of the Puerco formation.

CHAMPSOSAURUS SAPONENSIS, sp. nov.

Represented in my collection by six cervical and several dorsal vertebræ, one only of the latter with well preserved centrum, parts of ribs, and various other bones, whose reference is not yet certain.

The cervical vertebræ include the os dentatum or centrum of the atlas. This shows its streptostylicate character in its distinctness from both the centrum and the free hypapophysis of the axis. Nevertheless it is more Crocodilian than Lacertilian in form. Its anterior face is transverse, with a little lip carrying forwards the floor of the neural canal, below which the face is leveled posteriorly. The inferior surface is narrow and transverse, as though adapted for the anterior part of the hypapophysis of the axis. At each side it terminates in a prominent tuberosity, as though for the attachment of a cervical rib as in the Crocodilia. The anterior face is bounded posteriorly by a transverse groove which terminates in a fossa on each side. The posterior articular face of the os dentatum is wider than deep. The lateral angles of the superior face are rounded, and its median portion is concave.

The axis displays a large facet for the hypapophysis. Behind it the inferior middle line is not keeled, but is coarsely wrinkled longitudinally. The posterior edge of the hypapophysial facet is the most prominent part of the inferior surface. The posterior articular face is deeper than wide. This is true of the faces of all the cervical vertebræ. The latter gradually increase in size posteriorly, and the dorsals become larger. The articular faces of all the centra are regularly rounded and not contracted below. The five cervicals are strongly keeled below ; the keel of the third centrum being split up anteriorly into narrow ridges. On the sixth the keel is more prominent and acute. The dorsal is not keeled. A trace of the parapophysis appears low down on the fourth cervical ; it rises and becomes prominent as a round tuberosity on the fifth and sixth. It appears on the superior edge of the centrum of the dorsal vertebra, where it is connected with the diapophysis. It is near the middle of the length of the centrum, and not near the anterior border as in *C. australis.*

The surfaces of the vertebræ are very smooth excepting where thrown into coarse wrinkles near the borders of the articular faces and near the hypapophysis. The edges of the articular faces are somewhat revolute on the sides in the cervicals, but not on the dorsal. They are impressed in the centre to a point, most strongly so as we pass forwards in the series. There is a fossa below the space anterior to the parapophysis of the dorsal vertebra, which is abruptly bounded below by a horizontal angle. A separate neural spine perhaps of a cervical vertebra, has the following form. It is stout, and is contracted rather abruptly at the apex from behind forwards. The section is broadly lenticular, angulate in

front, and truncate behind. The posterior face has several longitudinal wrinkles, including a median raised line, and there are some more irregular wrinkles on the sides.

Measurements of vertebræ.			M.
Anterior face of os dentatum	width		.025
	depth (oblique)		.012
Posterior face of os dentatum	width		.020
	depth		.018
Length os dentatum above			.014
Diameters axis	posterior face	depth	.022
		width	.020
	length		.0185
Hypapophysial facet os dentatum	depth		.008
	width		.014
Diameters fourth cervical	length		.022
	anterior	depth	.0225
		width	.022
Diameters sixth cervical	length		.0215
	anterior	depth	.0245
		width	.0235
Spaces between parapophysis and diapophysis of do.			.0040
Diameters of dorsal	length		.0265
	anterior	depth	.0260
		width	.0265
Height of neural spine of ?, from postzygapophysis			.0210
Anteroposterior width of do. at base			.0100

The portions of ribs are separated heads and shafts. The former are double and therefore cervical, and are quite large. If the shafts belong to them, the neck of this species must have been wide. The shafts are slender and are of dense bone. The section is oval at the middle, but towards the distal extremity becomes flattened and grooved and delicately line ridged on one side. The extremities of the long bones are without condyles but have concave surfaces like those of the ribs. The bodies are robust and angular. They may be abdominal ribs of unusual stoutness. From the Puerco beds, D. Baldwin.

Published February 20th, 1882.

J. P. Lesley

(5)

Paleontological Bulletin, No. 35.

THE CLASSIFICATION OF THE UNGULATE MAMMALIA.

(Read before the American Philosophical Society, May 19, 1882.)

THIRD CONTRIBUTION TO THE HISTORY OF THE VERTEBRATA OF THE PERMIAN FORMATION OF TEXAS.

(Read before the American Philosophical Society, September 15, 1882.)

SYNOPSIS OF THE VERTEBRATA OF THE PUERCO EOCENE EPOCH.

(Read before the American Philosophical Society, October 20, 1882.)

ON THE SYSTEMATIC RELATIONS OF THE CARNIVORA-FISSIPEDIA.

(Read before the American Philosophical Society, October 20, 1882.)

By PROFESSOR E. D. COPE.

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The Classification of the Ungulate Mammalia. By E. D. Cope.

(*Read before the American Philosophical Society, May 19, 1882.*)

In the present essay the osseous system is chiefly considered, and of this, the structure of the feet more than of any other part of the skeleton. The ungulata are here understood to be the hoofed placental Mammalia with enamel covered teeth, as distinguished from the unguiculate or clawed and the mutilate or flipper limbed, and the edentate or enamelless, groups. The exact circumscription and definition is not here attempted, though probably the brain furnishes an additional basis of it in the absence of the crucial, parietoöccipital, calcarine fissures, etc. Suffice it to say that it is on the whole a rather homogeneous body of mammalia, especially distinguished as to its economy by the absence of forms accustomed to an insectivorous and carnivorous diet, and embracing the great majority of the herbivorous types of the world.

The internal relations of this vast division are readily determined by reference to the characters of the teeth and feet, as well as other less important points. I have always insisted that the place of first importance should be given to the feet, and the discovery of various extinct types has justified this view. The predominant significance of this part of the skeleton was first appreciated by Owen, who defined the orders *Perisso-*

dactyla and *Artiodactyla*. Professor Gill* has also used these characters to a large extent, but without giving them the exclusive weight that appears to me to belong to them. Other authors have either passed them by unnoticed, or have correlated them or subordinated them to other characters in a way which has left the question of true affinity and therefore of phylogeny, in a very unsatisfactory condition. Much light having been thrown on these points by recent discoveries in paleontology, the results, as they appear to me, are here given.

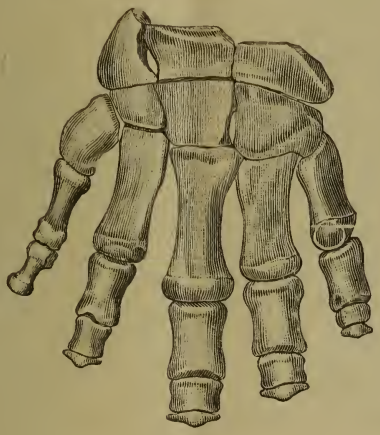


Fig. 1.

Fig. 1.—Left anterior foot of *Elephas africanus* (from De Blainville).

Carpus.—It is well known that in the *Perissodactyla* and *Artiodactyla*, the bones of the two rows of the carpus alternate with each other; that the lunar for instance rests on the unciform, and to a varying degree on the magnum, and that the scaphoides rests on the magnum and to some degree on the trapezoides and trapezium. It is also known that in the *Proboscidea*, another state of affairs exists; *i. e.*, that the bones of the two rows do not alternate, but that the scaphoides, lunar and cuneiform, rest directly on the trapezium and trapezoides, the magnum, and the unciform respectively. The preceding characters are sometimes included in the definitions of the respective orders. Further than this they have not been used in a systematic sense.

Professor Gill says of the carpus of the *Hyracoidea*, "carpal bones in two interlocking rows; cuneiform extending inwards (and articulating with magnum); * * * unciform and lunar separated by the interposition of the cuneiform and magnum." Professor Flower† gives a figure which justifies these statements, but neither the one nor the other agree with my

* Arrangement of the families of Mammals prepared for the Smithsonian Institution. Miscellaneous Collections 230. Nov., 1872.

† Osteology of the Mammalia, p. 266; fig. 92.

specimens. In the manus of a *Hyrax capensis* (from Verreaux, Paris), I find the following condition of the carpus. The bones of the two series are articulated consecutively, and not alternately; they do not interlock, but inasmuch as the magnum is a little narrower than the lunar, the latter is just in contact (anteriorly) with the trapezoides (centrale) on the one side, and the unciform on the other. My specimen agrees with Cuvier's figure of *Hyrax capensis* in all respects. It is probable that Professor

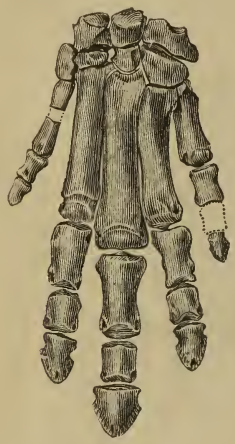


Fig. 2.

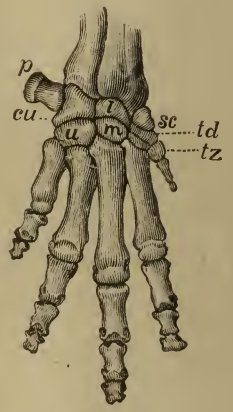


Fig. 3.

Fig. 2.—Left anterior foot of *Phenacodus primævus*, one-third natural size (original).

Fig. 3.—Right anterior foot of *Hyrax capensis;* (from Cuvier). *Sc.* scapuloid bone; *l.* lunar; *cu.* cuneiform; *p.* pisiform; *tz.* trapezium; *td.* trapezoides; *m.* magnum; *u.* unciform.

Flower has figured some other species under that name, which besides its peculiarities, is of smaller size than the *H. capensis* (see Fig. 3).

In April, 1875* I described the manus of *Coryphodon* (Bathmodon), showing that the lunar was supported below by the magnum and by parts of the unciform. This carpus has the characters of that of *Hyrax capensis*, with the last named articulation more extensive. This was the first description of the carpus of the *Amblypoda*. In February, 1876,† Professor Marsh described the carpus of *Uintatherium* (*Dinoceras*), and asserted that the bones "form interlocking series." He however states that "the magnum is supported by the lunar and not at all by the scaphoid," a state of things which does not belong to the interlocking carpus. The trapezoides does not join the lunar, but the unciform does so, as in *Coryphodon*. Professor Marsh's figure as to the articu-

* Systematic Catalogue of the vertebrata of the Eocene of New Mexico. p. 24 (U. S. Geol. Survey W. of 100th Mer.).

† Amer. Journal Sci. Arts. xi, p. 167; pl. vi., fig. 2.

lations of the magnum does not agree with his description, as it makes that bone articulate with the scaphoid. The second description is however correct, and the carpus is identical with that of *Coryphodon*. (Fig. 4.)

In the *American Naturalist*, June, 1882,* I have shown that the carpus of the *Condylarthra* is essentially like that of the *Hyracoidea*. (Fig. 2.)

Fig. 4.

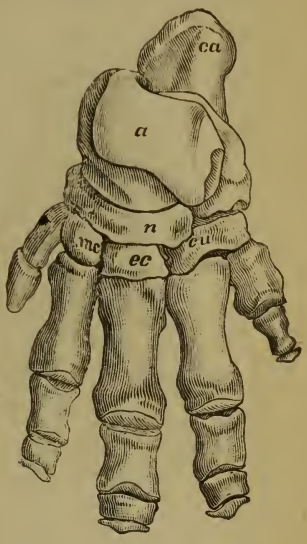


Fig. 5.

Fig. 4.—Manus of *Coryphodon* (original). The cuneiform is imperfect.

Fig. 5.—Left posterior foot of *Elephas indicus*; (from Cuvier). *ca.* calcaneum: *a.* astragalus; *n.* navicular; *cu.* cuboid: *ec.* ectocuneïform; *mc.* mesocuneïform.

Tarsus.—In the tarsus of the *Perissodactyla* and *Artiodactyla* it is well understood that the cuboid extends inwards so as to articulate with the astragalus, giving the latter a double distal facet. It is also well known that the astragalus of the *Proboscidea* has but a single distal articulation, that with the navicular. It is, however, true that the cuboid is extended inwards, but that it articulates with the distal extremity of the navicular, instead of that of the astragalus. It was shown by Cuvier that the astragalus of the *Hyracoidea* articulates with the navicular only, and that the cuboid is not extended inwards so as to overlap the latter. In 1873 Marsh† stated that the astragalus of the *Amblypoda* articulates with both cuboid and navicular. Finally I discovered in 1881,‡ that the astragalus of the *Condylarthra* articulates with the navicular only and that the cuboid articulates with

* Page 522.

† American Journal Science and Art, January, 1873.

‡ American Naturalist, 1881, p. 1017.

the calcaneum only. In the tarsus then there are four types of articula-

FIG. 6.

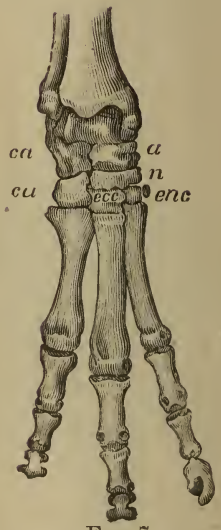


FIG. 7.

FIG. 6.—Left posterior foot of *Phenacodus primævus*, one-third natural size (original).

FIG. 7.—Right posterior foot of *Hyrax capensis* (from Cuvier). *Ca.* calcaneum; *a.* astragalus; *n.* navicular; *cu.* cuboid; *ecc.* ectocuneiform; *mc.* mesocuneiform; *enc.* entocuneïform.

FIG. 8.

FIG. 8.—Posterior foot of *Coryphodon* (original).

tion, which are typified in the *Condylarthra*, the *Proboscidea*, the *Amblypoda* and the *Artiodactyla* respectively. (Figs. 5–9.)

Fig. 9.

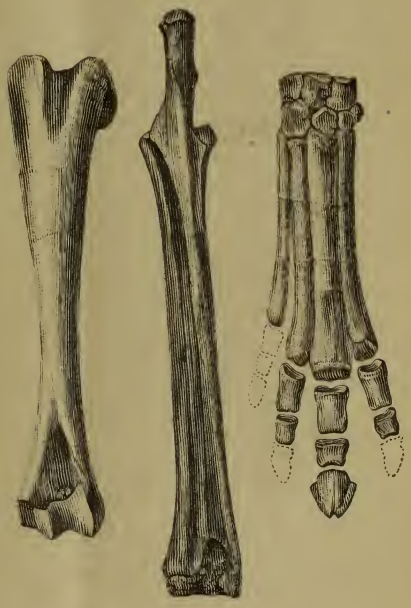


Fig. 10.

Fig. 9.—Hind foot of *Poëbrotherium labiatum* (original).
Fig. 10.—Fore leg and foot of *Hyracothertum venticolum* (original).

Orders.—From the preceding considerations we derive the following definitions of the primary divisions of the Ungulata, which should be called orders. In the first place I find the diversity in the structure of the carpus to be greater in the relations of the magnum and scaphoides, than in the relations between the unciform and the lunar. In other words the trapezoides and magnum are more variable in their proportions than is the unciform. This is directly due to the fact that the reduction of the inner two digits is more usual than the reduction of the external two. I therefore view the relations of these bones as more characteristic. In the tarsus the really variable bone is the cuboid. It is by its extension inwards

that the additional facet of the astragalus is produced. Its relations will therefore be considered rather than those of the astragalus in framing the following definitions :

Order I. Scaphoides supported by trapezoides and not by magnum, which supports lunar. Cuboid articulating proximally with calcaneum only..... *Taxeopoda.*

Order II. Scaphoides supported by trapezoides, and not by magnum, which supports lunar. Cuboid extended inwards and articulating with the distal face of the navicular..... *Proboscidea.*

Order III. Scaphoides supported by trapezoides and not by magnum, which with unciform, supports the lunar. Cuboid extended inwards and articulating with astragalus..... *Amblypoda.*

Order IV. Scaphoides supported by magnum, which with the unciform also supports the lunar. Cuboid extended inwards so as to articulate with the astragalus..... *Diplarthra.*

The sub-orders are defined as follows :

I. TAXEOPODA.

There are two, perhaps three sub-orders of the *Taxeopoda;* the *Hyracoidea,* the *Condylarthra,* and perhaps the *Toxodontia.** The *Toxodontia* are however not sufficiently known for final reference.† The sub-orders are defined as follows :

A postglenoid process ; no fibular facet of calcaneum, but an interlocking articulation between fibula and astragalus ; ungual phalanges truncate..... *Hyracoidea.*

A postglenoid process ; no fibular facets on either calcaneum or astragalus ; a third trochanter of the femur ; ungual phalanges acuminate..... *Condylarthra.*

There are a good many other subordinate characters which distinguish the *Condylarthra,* which will be given in my forthcoming volume iv of the Hayden Survey, on the Tertiary Vertebrata of Western America.

II. PROBOSCIDEA.

There may be two sub-orders of this order, the *Proboscidea* and the *Toxodontia.* I do not know the Carpus of *Toxodon,* but if it does not differ more from that of the elephants than the tarsus does ; it is not entitled to subordinal distinction from the Proboscidea. The sub-order of *Proboscidea* is defined as follows :

A fibular articulation of the calcaneum ; no postglenoid process ; no third trochanter of femur..... *Proboscidea.*

* See my remarks on Toxodon, Proceedings Amer. Philosoph. Society, 1881, p. 402.

† The considerable resemblance between the dentition of *Toxodon* and *Hyrax* must not be overlooked.

III. AMBLYPODA.

The sub-orders of this order, as I pointed out in 1873, are two, defined as follows :

Superior incisor teeth ; no ali-sphenoid canal ; a third trochanter of femur ; *Pantodonta.*

No superior incisors, nor ali-sphenoid canal, nor third trochanter of femur ; *Dinocerata.*

The difference between the *Proboscidea* and the *Amblypoda* consists chiefly in that the navicular of the latter is shortened externally so as to permit the cuboid to articulate with the astragalus. The cuboid has the same form in both. The peculiar character of the navicular gives the astragalus a different form.

IV. DIPLARTHRA.

This order is called by some authors the Ungulata, but that name is also used in the larger sense in which it is here employed. This appears to be its legitimate application, as the name should, if possible, be used for hoofed Mammalia in general, as its meaning implies. The two well known sub-orders are the following :

Astragalus truncate distally ; number of toes odd, the median one the largest.....*Perissodactyla.*

Astragalus with a distal ginglymus ; number of toes even, the median two largest.....*Artiodactyla.*

Phylogeny.—The serial arrangement of the bones of the carpus and tarsus seen in the *Taxeopoda*, is probably the primitive one, and we may expect numerous accessions to that order on further exploration of the early Eocene epochs. The modification seen in the more modern orders of *Perissodactyla* and *Artiodactyla*, may be regarded as a rotation to the inner side, of the bones of the second carpal row, on those of the first. This rotation is probably nearly coincident with the loss of the pollex, as it throws the weight one digit outwards, that is on the third and fourth digits, rendering the first functionally useless to a foot constructed solely for sustaining a weight in motion. The alternation of the two rows of carpals clearly gives greater strength to the foot than their serial arrangement, and this may probably account for the survival of the type possessing it, and the extinction of nearly all the species of the type which does not possess it. Here is applied again the principle first observed by Kowalevsky in the proximal metapodial articulations. This author shows that the types in which the metapodials articulate with two carpal or tarsal bones, have survived, while those in which the articulation is made with a single carpal or tarsal have become extinct. The double articulation is, of course, mechanically the more secure against dislocation or fracture.

As regards the inner part of the manus I know of no genus which presents a type of carpus intermediate between that of the *Taxeopoda* and

Amblypoda on the one hand, and the *Perissodactyla* and *Artiodactyla* on the other. Such will however probably be discovered. But the earliest *Perissodactyla*, as for instance *Hyracotherium*, *Hyrachyus* and *Triplopus*, possess the carpus of the later forms, *Rhinocerus* and *Tapirus*. The order *Amblypoda* occupies an interesting position between the two groups, for while it has the carpus of the primitive type, it has the tarsus of the later orders. The bones of the tarsus alternate, thus showing a decided advance on the *Taxeopoda*. This order is then less primitive than the latter, although in the form of its astragalus it no doubt retains some primitive peculiarities which none of the known *Taxeopoda* possess. I refer to the absence of trochlea, a character which will yet be discovered in the *Taxeopoda*, I have no doubt.

The *Taxeopoda* approach remarkably near the *Bunotheria*, and the unguiculate and ungulate orders are brought into the closest approximation in these representatives. In fact I know of nothing to distinguish the *Condylarthra* from the *Mesodonta*, but the ungulate and unguiculate characters of the two divisions. In the *Creodonta* this distinction is reduced to very small proportions, since the claws of *Mesonyx* are almost hoofs. Some of the genera of the *Periptychidæ* present resemblances to the *Creodonta* in their dentition also.

The facts already adduced throw much light on the genealogy of the Ungulate Mammalia. The entire series has not yet been discovered, but we can with great probability supply the missing links. In 1874 I pointed* out the existence of a yet undiscovered type of Ungulata, which was ancestral to the *Amblypoda*, *Proboscidea*, *Perissodactyla* and *Artiodactyla*, indicating it by a star only in a genealogical table. This form was discovered in 1881, seven years later, in the *Condylarthra*. It was not until later† that I assumed that the *Diplarthra* are descendants of the *Amblypoda*, although not of either of the known orders, but of a theoretical division with bunodont teeth.‡ That such a group has existed is rendered extremely probable in view of the existence of the bunodont *Proboscidea* and *Condylarthra*. That the *Taxeopoda* was the ancestor of this hypothetical group as well as of the *Proboscidea*, is extremely probable. But here again neither of the sub-orders of this group represent exactly the ancestors of the known *Amblypoda*, which have an especially primitive form of the astragalus not found in the former. In the absence of an ankle-joint, the *Amblypoda* are more primitive than any other division of the Ungulata, and their ancestors are not likely to have been more specialized than they. It is probable that a third sub-order of *Taxeopoda* has existed which had no trochlea of the astragalus, which I call provisionally by the name of *Platyarthra*.

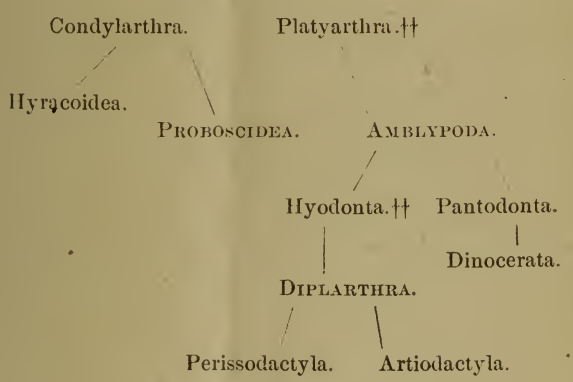
* Homologies and Origin of Teeth, etc., Journal Academy Nat. Science, Philada., 1874, p. 20.

† Report U. S. Geol. Survey W. of 100th Mer., p. 282, 1877.

‡ This hypothetical sub-order is called in the appended scheme, *Amblypoda Hyodonta*.

The preceding paragraphs were written in May of the present year. On my return home, September 1st, after an absence of three months, I find that various parts of the skeleton of *Periptychus** have reached my museum. On examination, I find that the astragalus of that genus fulfils the anticipation above expressed. *It is without trochlea*, and nearly resembles that of *Elephas*. As it agrees nearly with that of *Phenacodus* in other respects I only separate it as a family from the *Phenacodontidæ*. One other type remains to be discovered which shall connect the *Periptychidæ* and the hypothetical *Hyodonta*, and that is a Taxeopod without a head to the astragalus,—unless, indeed, the "*Hyodonta*" should prove to have such a head. I think the latter the less probable hypothesis, and hence retain the term *Platyarthra* for the hypothetical Taxeopod without trochlea or head of the astragalus.

These relations may be rendered clearer by the following diagram :



Third contribution to the History of the Vertebrata of the Permian formation of Texas. By E. D. Cope.

(*Read before the American Philosophical Society, September 15, 1882.*)

Since the publication of my second contribution to this subject,‡ I have described four additional species. These are, in Bulletin of the U. S. Geological Survey of the Territories ;§ *Pantylus cordatus* and *Dimetrodon semiradicatus ;* in the American Naturalist,‖ *Eryops reticulatus* and *Za-*

* See American Naturalist, October, 1882

†† Hypothetical.

‡ Paleontological Bulletin, No. 32, Proceedings American Philosophical Society, 1880; the plates, 1881.

§ Vol. vi, 1881, p. 79.

‖ 1881, p. 1020.

trachys apicalis. The last two were not included in my catalogue of the Permian Vertebrata published previously* in the same year. The present paper adds some important points to this remarkable fauna, and explains the hitherto obscure relations of several genera.

DIADECTIDÆ.

The pelvis and sacrum of a species of this group are preserved in my collection, and they indicate further peculiarities of this group,

The sacrum consists of two vertebræ only, and is thoroughly united with the pelvis by its transverse processes. The latter are decurved on the inner side of the iliac bones, and the sutures which distinguish them from the latter and from each other, are not serrate. The inferior arch is robust, but very narrow anteroposteriorly. The acetabulum is entire in every respect, so that it is probable that both pubis and ischium are united undistinguishably in the arch. The pubis is perforated by the usual internal femoral foramen. The posterior edge is grooved, and it might be suspected that this marks the articulation of an ischium. The anterior edge is however grooved in the same way, so that the appearance is rather the position of muscular insertion. The spines of the sacral vertebræ are distinct, and have the usual form seen in *Diadectes*.

The two sacral vertebræ and the absence of obturator foramen, are characters of the suborder *Pelycosauria* in which the latter differs from the *Dicynodontia*. I am still inclined to question whether the extraordinary characters of the cranio-vertebral articulation I have described, justify the separation of the *Diadectidæ* as a third sub-order of the *Theromorpha*, which I have called the *Cotylosauria*,† or whether they are not due to the loss of a loosely articulated basioccipital bone.

EDAPHOSAURUS Cope, genus novum.

Apparently allied to *Pantylus*. Temporal fossæ not overroofed; surfaces of cranial bones not sculptured. Mandibular and maxillary teeth subequal. Posterior half of the mandibular ramus expanded inwards and supporting numerous closely arranged teeth. Pterygoid, or perhaps an internal expansion of the malar bones, supporting a dense body of teeth, corresponding to those of the lower jaw. Teeth subconical.

The single species of this genus in my possession shows the following characters of systematic importance. An arch extends from the parietal plane posteriorly and downwards to the external base of the quadrate. The specimen is not yet in a condition to show how much of this is parietal, and how much squamosal or opisthotic. The proximal half of the posterior part of this arch is a distinct element, perhaps a transverse process of the supraöccipital. A distinct element connects the basioccipital on each side with the quadrate. The articular extremity of the latter has

* American Naturalist Feb., 1881.
† American Naturalist, 1880, p. 304.

a deep anteroposterior concave emargination. There is a flat bone extending from it anteriorly which is apparently pterygoid rather than quadratojugal. The tooth bearing portion terminates opposite the middle of the basisphenoid.

The occipital condyle is undivided, and the basisphenoid presents the usual two divaricating protuberances to the basioccipital.

EDAPHOSAURUS POGONIAS, sp. nov.

Represented by the followsng portions of a skull; basis cranii with portion posterior to the middle of the parietal bone; left maxillary with dental plate, left mandibular ramus entire; various flat bones undetermined. There is also a body which may be the atlas with its arch somewhat dislocated. These pieces are in part covered with a thin layer of the red deposit of the Permian bed in which they occur.

The facial plate of the *os maxillare* is subvertical, so that the orbit is lateral. The latter is rather small. The malar bone is narrow, and is continuous with the dentigerous bone of the palate. The latter has a thickened posterior edge, which commences below the anterior part of the orbit, and extends posteriorly to the middle of the basisphenoid. Thence the border turns forwards. Its anterior edge is below the anterior border of the orbit, and the general form is a longitudinal oval. The maxillary teeth are somewhat weathered and obscured by a thin layer of matrix. The posterior ones are compressed-conic; the premaxillaries are four in number on one side, and are more nearly conic, and have incurved apices. The median premaxillary suture is, however, not clearly defined, so that the number of premaxillaries remains uncertain. The centre of the probable nostril measures one-third the distance from the premaxillary border to the anterior edge of the orbit. There are eight rows of (?) pterygoid teeth at the posterior fourth of the series. The teeth are subequal and obtuse, increasing a little anteriorly.

The mandibular ramus is robust, and the external face slopes inwardly and downwards. The external border rises a little above a few of the posterior teeth, but it is injured at the posterior of the coronoid process, so that its existence cannot be ascertained. The border then descends and turns inwards to the articulation, which is condyloid at its internal extremity. The inferior edge of the anterior part of the ramus becomes a median ridge below the condyloid region, and terminates in a short, compressed angular process. The symphysis is not coössified, and is convex downwards and forwards. The inferior part is subhorizontal, and forms the edge of a transverse plate which is separated from the vertical part of the ramus by a deep groove. The inner vertical face of the ramus is strongly convex, as is the corresponding edge of the symphyseal suture The apices of the teeth are worn, but they were probably conic, the posterior gradually smaller and more obtuse. The interior face of packed teeth begins at the posterior two-fifths of the external series, and expands in-

wards posteriorly. It contains six longitudinal rows opposite the antepenultimate dentary tooth.

All the bony surfaces are smooth.

Measurements.	M.
Length of mandibular ramus (straight)	.162
" symphysis of do. (straight)	.038
" external dental series	.077
Width of ramus at dental pavement	.040
" skull at ends of OO. quadrata	.138
" extremity of O. quadratum	.024
" occipital condyle	.018
Length of superior dental pavement	.065
Width of basisphenoid posteriorly	.029

The supposed axis vertebra is longer than wide, and the centrum is deeply excavated posteriorly. Anteriorly it appears to have lost a piece—the centrum of the atlas, which, while fitting it closely, was not co-ossified with it. There is a flat horizontal convex ala in the place of a diapophysis, and an obtuse median hypapophysial angle. The neural spine is compressed, except posteriorly, where it is transversely expanded, terminating above in a short obtusely accuminate apex. From this apex an obtuse rib passes down the median line, and disappears above the neural arch, where the spine is somewhat narrower. The postzygapophyses are well developed and look downward.

Measurements of axis.	M.
Length of centrum below	.020
Width, including diapophyses	.035
Elevation of spine from postzygpophysis	.038
Width of do., posteriorly	.020

Remarks.—This interesting form is probably allied to *Pantylus*, which I have hitherto regarded as a Batrachian. The two genera may be placed in a special family of the Pelycosauria, to be called the *Edaphosauridæ*. This family will be distinguished from the *Clepsydropidæ* by the presence of more than one series of teeth on parts of the jaws. It is possible that *Helodectes* must be placed in it.

ECTOCYNODON Cope.

Paleontological Bulletin No. 29, p. 508.

A species now before me resembles in generic characters the type of this genus, *E. ordinatus*. That species was described as having the canine tooth near the middle of the maxillary bone, while in the present one it is near the anterior part of it, as in some other genera. In the typical species, as in the species to be described, the cranial bones are sculptured, and the temporal fossæ are overroofed. The sculptured surface as well as the canine teeth distinguish *Ectocynodon* from *Pariotichus* Cope and *Procolophon* Owen, which genera are otherwise related.

ECTOCYNODON AGUTI, sp. nov.

This reptile is much larger than the *Pariotichus brachyops*, and the anterior part of the cranium has a different form. The general shape of the head is much like that of a rodent mammal of the genus *Dasyprocta*. It is rather wide at the temporal regions, flat above, and narrowed and compressed anterior to the orbits. The muzzle is narrowed and obtuse, and the nostrils are terminal, and are lateral and a little anterior in direction. The maxillary alveolar edge is nearly straight, but the premaxillary edge, beginning below the posterior border of the nares, descends forward at an angle of 45°. Viewed from the front, the premaxillary border is a festoon, strongly convex downwards, and below the anterior part of the nostril. The suture separating the premaxillaries is distinct. The orbits are of moderate size, as in an aguti, and invade the superior frontal plane in a slight degree. The frontoparietal fontanelle is rather large.

The mandible is robust, and presents a short angle. It closes up behind the premaxillary lobate edge. Its teeth are concealed in the specimen. The maxillary teeth increase rapidly in size forwards. The premaxillaries commence smaller next the maxillaries, and increase in size to the first, which is a little larger than the anterior maxillary. The crowns are weathered away. The sculpture on the maxillary and malar bones consists of closely placed shallow fossæ. On the posterior part of the frontals there are strong ridges radiating posteriorly, and situated close together.

Measurements.	M.
Length of skull to end of angle of lower jaw	.090
" " frontoparietal fontanelle	.056
" " orbit, above	.026
" ramus mandibuli	.082
Depth of skull at orbit	.033
" ramus "	.019
Width of skull posteriorly	.068
" " between orbits	.017
" " between external nares	.0105
Diameter of first premaxillary tooth	.003
" second maxillary tooth	.003
Six fossæ of the malar bone	.005
Seven grooves of the frontal bone	.005

This species is much larger than the *Ectocynodon ordinatus* Cope, and the canine tooth has a more anterior position.

Discovered by W. F. Cummins.

DIPLOCAULUS Cope.

Paleontological Bulletin No. 26. p. 187, Nov. 21st, 1877. Proceedings American Philos. Society, 1877, p. 187.

This genus was characterized by me at the places cited, as follows: "Vertebral centra elongate, contracted medially, and perforated by the

foramen chordæ dorsalis, coössified with the neural arch, and supporting transverse processes. Two rib articulations, one below the other, generally both at the extremities of processes, but the inferior sometimes sessile. No neural spine nor diapophysis; the zygapophysis normal and well developed."

This diagnosis was derived from the vertebræ of a single species from the Clepsydrops shale of Illinois, the *D. salamandroides*, and since that description was written, no additional specimens have come under my observation. In the Catalogue of the Vertebrata of the Permian I placed the genus as the type of a family, the *Diplocaulidæ*, among the Pelycosauria. I am now, however, through the energy of Mr. W. F. Cummins, in possession of specimens of a number of individuals of a second species of *Diplocaulus*, found by him in the Permian beds of Texas. From them I derive that the genus and family must be referred to the Stegocephalous Batrachia. It is, however, exceptional among these in the fauna of which it is a member, in not belonging either to the Rhachitomi* or to the Embolomera, since the vertebral centra are not segmented, nor are the intercentra present in any form. Under these definitions it must be referred to the suborder which includes *Oëstocephalus*, *Ceraterpeton*, etc., for which I have adopted Dawson's name Microsauria. The division includes genera with simple amphicœlous vertebral centra, and teeth without inflections of the dentine. The following characters must be added to *Diplocaulus*:

Vertebræ with a more or less perfect zygosphen articulation; centra shorter in the anterior than in the median part of the column; axis and atlas solidly united by a long zygosphen, which is not roofed over by the zygantrum. Neural arch continued as a short tube into the foramen magnum. Atlas unsegmented, and, like the axis, without free hypapophysis. Cervical vertebræ not distinguished from dorsals, and with two-headed ribs.

Orbit separated from the maxillary bone by the union of the lachrymal and malar. Either the malar, or more probably the quadratojugal, extends much posterior to the quadrate bone. It is bounded above by the squamosal, which extends anteriorly to the distinct postfrontal, thus covering over the temporal fossa. Posteriorly it extends into a long, free process, like the operculum of *Polyodon* ossified. This horn does not appear to consist of the epiotic as appears to be the case in *Ceraterpteon*. The quadrate bone is extended very obliquely forwards and its extremity is divided into an hourglass-shaped condyle. In other words the condyle consists of two cones with apices continuous. The internal cone is the smaller, and its base is overlapped from before by a flat bone, probably the pterygoid. The cotyli of the mandible correspond. Mandible without angle; symphysis short.

The teeth are of about equal size, and are rather slender and with conical apex. Their surface is not inflected at any point. The superior series is

* American Naturalist, 1882, p. 334.

double, forming two lines between which the mandibular teeth close. This superior series stands near the external edge of the vomer, palatine and pterygoid bones successively. I have not been able to find any larger teeth in the jaws in this genus. Some fragments mingled with those here described, display such teeth, but I think they pertain to a species of another genus. I know nothing of the limbs of this genus.

DIPLOCAULUS MAGNICORNIS, sp. nov.

The species is indicated by fragments of a number of crania, and portions of several vertebral columns. These were collected at two different localities by Mr. W. F. Cummins.

The skull is very peculiar in the great extent of the parts posterior to the orbits as compared with the portion anterior to them. The posterior border not being complete, the proportions cannot be exactly given, but the part anterior to the orbits is two-thirds the length of the part extending from their posterior border to near the base of the lateral horn, and one-fifth the distance from the orbit to the extremity of the horn. The part of the border of the orbit preserved indicates that the latter is of fair size. It is separated from the maxillary border by at least its own diameter. The external nares are peculiarly situated. They are nearer the orbit than the end of the muzzle, and are close to the maxillary border, being separated from the mouth by a narrow strip of bone only. They are round, open nearly laterally, and are removed from the edge of the orbits by the diameter of the latter.

The malar or quadratojugal bone is protuberant at the canthus oris and projects laterally beyond the mandible at its posterior part. It also projects beyond the extremity of the quadrate bone. This border is continued as that of the external base of the horn, but the portion which belongs to this element is soon distinguished from the superior element (squamosal) which composes the horn, by a groove. This groove is decurved, and bounds the apex of the element, which is a decurved, low tuberosity[1] The horn is produced backwards in a horizontal plane, forming a long fla triangle which contracts gradually with straight sides. The apex is narrowed, obtuse, and a little incurved. Near and at the extremity the horn is flat above and convex below.

The mandibular quadrate cotylus consists of two fossæ, which together form an approximate figure ∞, of which the internal fossa is the smaller, and opens internally. The external one is nearly transverse. The superior border of the ramus posteriorly is straight. The greater part of the superior aspect is occupied by a huge fossa which opens upwards.

It is uncertain whether the horns meet at an entering angle on the middle line posteriorly or not, but the width of the base of the horn indicates that such is the case. The extremity of the muzzle is depressed, and is broadly rounded.

The external surface of the skull is sculptured in the form of fossæ so distributed that the narrow ridges separating them do not form straight

lines, except in a few places on the superior face of the horn. This sculpture is strongly impressed, and is of medium coarseness. It extends on the inferior face of the quadratojugal (?) posterior to the quadrate, and on the inferior side of the horn at the edges. It is most extended below from the interior edge, and for the terminal inch of the horn, is as well marked as on the superior face. Elsewhere the sculpture of the inferior side passes into punctæ before disappearing. A groove marks the superior boundary of the maxillary bone, which divides when it reaches the superior surface. One branch descends behind the nostril, the other passes transversely across the lachrymal bone and shallows out before reaching the middle line of the muzzle. The mandible is even rougher than the superior surfaces, and has a longitudinal groove below the dental line, to near the symphysis, where it runs out on the alveolar edge. The internal and external sides of the mandible posteriorly, are smooth. On the malar and other facial bones there are four fossæ in 9 or 10 mm.

The atlas is peculiarly flattened above, the neural arch being a tube, without neural spine. Its anterior tubular prolongation is not long, and is deeply notched below. The condyloid fossæ are widely spread transversely and nearly flat, except that their surface is carried forwards on the neural tube. They are well separated below. There is a strong hypapophysial keel, which diminishes and runs out anteriorly. There are prezygapophysial facets, but the postzygapophyses exist. Their superior edge is however carried posteriorly to form the sides of the huge embracing zygantrum. These side processes, which I will call zygantropophyses, extend as far posteriorly as above the posterior end of the centrum of the axis, embracing almost the whole of the neural arch. There is another short median superior process, which notches the extremity of the zygosphen. The side of the atlas between the postzygapophysis and the condyloid facet is wrinkled, and the inferior face finely punctate.

In the axis, the hypopophysis is a large ridge with a horizontal truncate edge. The costal heads of the diapophysis are not split to the base of the latter and the superior is the more robust (extremities broken off). Centrum concave posteriorly, and on each side of hypopophysis with reticulate surface. A short zygantropophysis; zygantrum not large. Exposed summit of zygosphen (nearly equal neural arch) without neural spine. In both the axis and other cervical vertebræ, the superior diapophysis is connected with the zygapophyses fore and aft, in accord with the shortness of the centra. In the more posterior vertebræ they become separated on account of the increasing length of the centrum.

The third vertebra is like the axis, except in having a keel-shaped neural spine, and a short obtuse zygosphen continued from its base anteriorly. With increasing length of centrum the diapophysis becomes longer, and the hypapophysial ridge becomes wider, and coëxtensive with the inferior face of the centrum. It is separated by an angle from the sides in the longer vertebræ; in those of intermediate length, the inferior face is

convex. All of them retain the delicate lines and punctæ of the inferior surface. The neural spine on the more elongate vertebræ is a rather elevated keel, with horizontal superior edge. Its posterior extremity forms a wedge-like zygosphen. The zygantrum is a deep V-shaped cavity, opening posteriorly and not roofed over at any point unless for a small part of its fundus. The zygapophyses are well spread, and have horizontal faces. Each of the columns of the diapophysis sends a ridge forwards, which encloses a groove between them.

Measurements of vertebræ.	M.
Length of atlas below	.015
" " at zygantropophyses	.029
Expanse " " condyloid facets	.034
" of centrum atlas behind	.0145
Depth of atlas at middle	.019
Length of axis below	.015
" " at zygantropophyses	.016
Width of zygosphen above	.011
Expanse of postzygapophyses	.024
Width of centrum posteriorly	.012
Depth " "	
Length of centrum of another (No. III)	.018
" " " (No. IV)	.022
Expanse of postzygapophyses of do	.018
Length of centrum of No. V	.022
Diameters centrum V anteriorly { vertical	.013
Diameters centrum V anteriorly { transverse	.012
Expanse prezygapophyses	.021
Elevation of neural spine from centrum	.011
Diameters centrum No. VI { anteroposterior	.023
Diameters centrum No. VI { vertical	.011
Diameters centrum No. VI { transverse	.013

The vertebræ of this species are very much larger than those of the *D. salamandroides*, and the diapophyses do not originate so low down on the centrum. Otherwise they are much alike. The cranium of the Illinois species is yet undetermined.

The *D. magnicornis* was discovered by W. F. Cummins.

ACHELOMA. Cope, genus novum.

Order Rhachitomi; family Eryopidæ,* differing from *Eryops* in the absence of notch of the posterior border of the skull between the epiotic and quadrate or squamosal bones, and in the absence of condyles of the humerus.

Mandible without angular process. Teeth of the jaws subequal, rather larger anteriorly; some large ones on the *os palatinum* at different points

* American Naturalist, 1882, p. 335.

along the external margin. Pterygoid bone ending in a free decurved edge anterior to the quadrate bone. Palatines and pterygoids narrow, leaving a wide palatal foramen. Vertebræ in their principal features as in *Eryops*. The humerus is unlike any of those enumerated in my synopsis of Permian humeri,* but resembles the one figured by Gaudry as belonging to *Actinodon*, except that in *Acheloma* there are no condyles, and there is an epicondylar foramen. This is the first time I have observed the foramen in a Batrachian, though it is universal, so far as known, in the Pelycosauria. As in *Actinodon*, there is a short process above the external epicondylar angle.

The absence of humeral condyles in this genus is paralleled by the same feature in *Clepsydrops natalis*. It looks as though the animal were young, and had not yet attained to the coössification of epiphyses. This theory may account for the condition of the humeri in the two species mentioned. It occurs equally in the *Trimerorhachis insignis*. As all these species show every other indication of maturity, and as I have never yet observed free epiphyses in any of my numerous Texan collections, I am disposed to look on this condition of the humeri as a case of permanent incompleteness, of which the Batrachia present so many instances.

Acheloma cumminsi, sp. nov.

This animal is represented by a greater part of a skull and vertebral column, with both humeri and scapulæ and various other bones of the limbs, including phalanges. All of these remains look a good deal like *Eryops megacephalus*, and they might be supposed on hasty examination to belong to the young of that species. On a full investigation the following differences appear, besides those already mentioned in the generic diagnosis.

The muzzle is relatively much shorter, and the extremity is less depressed; the length from the supraöccipital forwards, is a little less than the total width at the same point. In agreement with this, the mandibular rami, after diverging strongly from the symphysis, are strongly incurved to the quadrate, a form not found in *E. megacephalus*. The sculpture is more sharply defined in the present species. In the vertebræ, although the intercentra have the same degree of ossification as in the *E. megacephalus*, the neural spines have not the expanded head of those of the larger species, but look as though they had lost an epiphysis, as in the case of the humeri. They are erect, with subquadrate section, and not oblique and grooved as *Trimerorhachis insignis*. The diapophyses are more elongate than in *E. megacephalus*, and their extremities frequently have a subround or suboval section, and but few have the narrow surface seen in *E. megacephalus*. The ribs are short and flat, and have the distal extremities expanded paddle-shape. Laid backwards such a rib reaches to the posterior edge of the third diapophysis posterior to the one to which it is attached.

* Proceedings American Philos. Soc., 1878, p. 528.

The form of the skull is triangular, with rounded apex or muzzle, and a slight contraction behind the nostrils. The latter are near the edge of the jaw and open equally laterally and superiorly. The orbits are of medium size, and are as far from the edge of the jaw as the width of the interorbital space, which is about as wide as the diameter of an orbit. The posterior "table" is flat with decurved lateral edges, which rest in a squamosal suture on the squamosal or quadratojugal and quadrate bones. Its posterior angle is produced downwards and backwards to near the distal extremity of the quadrate. The latter slopes posteriorly and downwards. The quatratojugal region is strongly convex in vertical section. The mandibular ramus is strongly incurved posteriorly, from a point opposite the free extremity of the pterygoid. The symphysis mandibuli is short.

The sculpture is distinct on all the superior surfaces of the skull, and consists of fossæ of medium size, bounded by irregular narrow ridges. There are three fossæ in 10 mm. The fossæ are obsolete on the extremity of the muzzle and on the anterior part of both jaws.

The teeth are a little longer on the premaxillary than on the maxillary bone. There are five on each, or six, if the tooth below the nostril belongs to the premaxillary bone, The palatine teeth are much larger. The first, perhaps standing on the external edge of the vomer, is a little posterior to the line of the external nostril. The second is half way between the nostril and orbit, and the third is alongside of and just posterior to it. The fourth is opposite a point a little posterior to the middle of the orbit. Their surface is as yet obscured by a thin layer of fine indurated mud, which in some instances cannot be removed without destruction of the tooth surface.

The intercentra of the vertebræ are, as in *Eryops megacephalus*, ossified so as to nearly cut off the chorda dorsalis, but unlike that species they are not notched on one side of their lateral apices. The extremities of the neural spines are subquadrate, rounded behind, and flattened anteriorly. The edges of the postzygapophyses are prominent and flared upwards.

The scapula is robust and flat, having the posterior-external border longest, and concave, and the superior-posterior, convex. In my specimens the thin anterior edge is broken. The coracoid appears to be coössified with the proximal external edge of the scapula, and is directed downwards and backwards. Its extension is small, and terminates in an apex posteriorly, and a thick double edge inferiorly. The glenoid cavity borders this edge, and is small. The epicoracoid if it existed, is lost. The thick inferior edge of the coracoid and scapula, is similar to those of the humerus and vertebral processes, which suggest a cartilaginous cap. The position of the scapula and coracoid is peculiar. If the glenoid cavity is directed outwards, the ribs adherent to them fit their extremities, from which they have been broken, which adhere to the vertebræ. This is probably the natural position. When thus placed, the plate of the scapula is horizontal transversely, and inclined upwards and posteriorly at 30°. The coracoid

is vertical. When in place, there is a large tuberosity above and anterior to the glenoid fossa, immediately behind which is a wide shallow fossa.

The curve of the proximal extremity of the humerus is a semicircle. That of the distal end is less convex, being flattened at the middle. Viewed proximally the proximal end is a little concave on one side, and one extremity of the articular surface is expanded and rounded. Viewed distally, the distal extremity is angulate concave, the middle portion being straight and the extremities bent in the same direction, one being longer than the other, and neither expanded. The entire extremity makes an angle of 90° with the plane of the proximal end. The epitrochlear foramen is protected by a strong bridge.

Measurements.

Skull.	M.
Length to line of angles of mandible	.188
" posterior edge of supraöccipital	.168
" line of posterior edge of orbit	.121
" " anterior edge nares	.017
" " extremity of pterygoid	.142
Width of skull at angles of mandible	.134
" " , greatest	.158
" " just behind nares	.051
" " at nares	.054
" of cranial table at middle	.086
" between orbits	.030
Length of a premaxillary tooth	.011
Diameter of base of do	.004
Length of a median maxillary tooth	.007
Diameter of base of do	.004
Length of a median palatine tooth	.021
Diameter of same at base	.009
Depth of ramus mandibuli at angle	.015

Vertebræ and Ribs.

Diameters of intercentrum	transverse		.018
	antroposterior		.010
Total elevation of same vertebra			.027
Elevation of neural spine above postzygapophysis			.005
Total expanse of diapophyses of same			.027
Length of diapophysis from postzygapophysis			.0095
Diameter of end of	neural spine		.206
	diapophysis	transverse	.004
		vertical	.006
Length of rib of 5th vertebra in advance of the vertebra measured			.038
Width of rib distally			.027

Scapular arch.	M.
Length of scapula on anterior face	.069
Width do. at antero-internal distal angle, transversely.	.032
" of coracoid and epicoracoid at glenoid cavity, from edge of scapula	.023
Length of epicoracoid and coracoid	.037
" humerus	.064
Width of shaft at middle	.016
Diameters proximal end { long	.039
Diameters proximal end { short at middle	.010
Diameters distal end { long	.039
Diameters distal end { short at middle	.010
Length ungual phalange	.004
" second "	.0075
" first "	.0135
Width do. { proximally	.010
Width do. { distally	.008

This species was discovered by Mr. W. F. Cummins, to whom I dedicate it with much pleasure.

ANISODEXIS Cope, genus novum.

Class Batrachia; order Rhachitomi; family Eryopidæ. Teeth on premaxillary, maxillary, and dentary bones of unequal lengths, some very large, others very small. Dentinal inflections straight, nearly reaching the pulp cavity. Cranial surfaces sculptured.

This genus differs from all the others of the *Eryopidæ*, in the great and abrupt inequality of the teeth of the external series of the mouth, resembling in this respect some of the Saurians of this deposit, rather than the batrachia. Whether it possesses long palatine or pterygoid teeth such as most of the latter exhibit, is not rendered clear by the specimens, but appearances indicate the presence of one near the anterior part of the maxillary. Mandibular series simple.

ANISODEXIS IMBRICARIUS Cope, sp. nov.

Founded on numerous fragments of the skull with jaws, and a vertebral arch and spine found in connection with the remains of the *Diplocaulus magnicornis*. These pieces indicate a larger species than the latter, and are nearly equal to the *Eryops megacephalus*. The jaws are not preserved entire, but portions from different parts of the length display the dental characters.

The sculpture of such parts of the superior surface of the skull is a coarse reticulation, coarser than in any other species known to me. Near the edges, some of the bones become smoother, and the ridges flatten into overlapping laminæ. The entire sculpture of the dentary bone is of this imbricate character, the apparent overlapping being from before back-

wards, and below upwards. This is totally different from what is observed in the other known species of *Eryopidæ, Trimerorhachidæ,* and *Diplocaulidæ.* The teeth are round in section, but become lenticular near the apex, developing low cutting edges. The basal grooves are fine, but distinct, and extend half way to the apex, or farther. One large, and one medium sized teeth stand on each dentary bone near the symphysis, and there are two similar ones at a point further back on the same bone. Near the anterior part of the maxillary, below the ?nostrils, is a huge tooth, with a graduated series of small teeth posterior to it, and a very small one anterior to it.

The neural arch of a vertebra has a well developed vertical spine. Its neurapophysis rested in an oval fossa of the centrum which probably was divided into pleurocentra. The prezygapophyses are very small, and look directly upwards. The postzygapophyses are much larger, and look obliquely outwards and backwards. The spine is not expanded at the summit, and is granular, as though it was protected by a cartilaginous cap. Its section is anteroposteriorly lenticular, with acute edge (angle) posteriorly, and a very narrow truncate edge anteriorly. The latter is bounded below just above the root of the neural arch by two little fossæ. The posterior keel is bounded below by a corresponding single fossa. The posterior acute edge of the spine is dentate, and the surface on each side of it, is beveled with rabbeted surfaces as though for a coarse squamosal suture. But the appearance of suture is fallacious, and is simply due to contraction of the transverse diameter of the spine. The neurapophysis is much narrower anteroposteriorly than the neural spine.

Measurements.	M.
Depth of maxillary bone at large anterior tooth	.037
" dentary at symphysis	.025
" " near middle	.021
Width " " "	.015
Diameter of base of large maxillary tooth	.010
" " small maxillary tooth	.0035
Length " " " "	.008
" of large mandibular tooth near symphysis	.016
Diameter of base of crown of do	.006
Elevation of neural arch	.037
Diameters neural spine { vertical	.029
Diameters neural spine { at apex { anteroposterior	.019
Diameters neural spine { at apex { transverse	.012
Width neurapophysis anteroposteriorly	.010

From Mr. W. F. Cummins' collections.

I had thought at one time that this species might be referable to the genus *Leptophractus* of the Coal Measures. No trace of the vertebræ of the Rhachitomous order has yet been found in that formation in this country, nor have any of the Coal Measure genera of Batrachia yet been found in

the Permian of the United States.* It is not improbable that such occurrence of genera may yet be substantiated, but the identification of an order hitherto unknown in a formation, on uncertain characters, is not a safe proceeding. The vertebræ of *Leptophractus* although not certainly known, are supposed to be of the Labyrinthodont type. The teeth are much more compressed and trenchant than in the present species, nor do there appear to be any long ones near the symphysis mandibuli. I consider the question of reference to Leptophractus to be still an open one.

The family *Eryopidæ*, though abundant in individuals, is not represented by many species. They are presumably as follows :

Anisodexis imbricarius Cope.
Acheloma cumminsi Cope.
Eryops reticulatus Cope.
Eryops ferricolus Cope (*Parioxys olim*).
Eryops megacephalus Cope.
Actinodon frossardi Gaudry.
Zatrachys serratus Cope.
Zatrachys apicalis Cope.

But the occipital condyles are unknown in *Acheloma* and *Zatrachys*.

I may add here that through the courtesy of Messrs. Scott and Osborne, I have seen, in the Museum of Princeton College, vertebræ of some species of the Rhachitomi from Saarbrücken, along with *Archegosaurus*, with entire centra, from the same locality.

Synopsis of the Vertebrata of the Puerco Eocene epoch. By E. D. Cope.

(*Read before the American Philosophical Society, October 20, 1882.*)

REPTILIA.

CROCODILIA.

Crocodilus sp.
Crocodilus sp.
Crocodilus sp.

TESTUDINATA.

Plastomenus ? communis Cope.
Dermatemys sp.
Compsemys sp.
Emys sp.

* *Peplorhina arctata* Cope, from the Illinois Permian is not a *Peplorhina*, but a Theromorph Saurian.

CHORISTODERA.

Champsosaurus australis Cope, American Naturalist, 1881, p. 690.
Champsosaurus puercensis Cope, Proceedings American Philosophical Society, 1881, p. 195.
Champsosaurus saponensis Cope, Loc. cit. 1881, p. 196.

MAMMALIA.

MARSUPIALIA.

Ptilodus mediaevus Cope, American Naturalist, 1881, p. 922.
Ptilodus trovessartianus Cope, loc. cit. 1882, p. 686.
Catopsalis foliatus Cope, loc. cit. 1882, p. 416.
Catopsalis pollux Cope, loc. cit. 1882, p. 685.
Polymastodon taöensis Cope, loc. cit. 1882, p. 684.

BUNOTHERIA.

TAENIODONTA.

Hemiganus vultuosus Cope, loc. cit. 1882, p. 831.
Tæniolabis scalper Cope, loc. cit. 1882, p. 604.

TILLODONTA.

Psittacotherium multifragum Cope, l. c., 1882 p. 156.
Psittacotherium aspasiæ Cope, Proceed. Amer. Philosophical Society, 1882, p. 192, (1882).

MESODONTA.

Pelycodus pelvidens Cope, Proceeds. Amer. Philos. Soc. 1881, (1882) p. 151. *Lipodectes pelvidens* Cope, American Naturalist. 1881, p. 1019.
Hyopsodus acolytus Cope, sp. nov.

This the least species of the genus, is also the oldest, being derived from the Puerco horizon. Parts of two individuals furnish the characters of the inferior and superior true molars, and the fourth superior premolars. The species differs from those hitherto described in other characters than the minute size. One of these is the absence of posterior interior cusp, the heels of the first and second true inferior molars being bounded by a ridge only at this point, as in most of the species of *Pelycodus*. The last inferior molar is not smaller than the second, nor longer. The anterior cusps of all the molars are robust, so that on the first and second true molars they are separated by a shallow notch only. There is a rudiment of the anterior inner cusp on the first true molar but none on the second and third. The posterior external is obtuse and has a triangular section on all the molars; a crest is continued from the heel of the third molar on the inner side of the crown half way to the anterior inner cusp.

The *Microsyops spiciuus* differs from this species in its smaller size (true molars .008) and in the presence of posterior internal cusps of the true molars.

The *Hyopsodus acolytus* was found by Mr. D. Baldwin, in New Mexico.

Creodonta.

Sarcothraustes antiquus Cope, Proceeds. Amer. Philos. Soc. 1881 (1882), p. 193.

Dissacus carnifex Cope, Amer. Natst. Oct. 1882 (Sept.), p. 834.

Dissacus navajovius Cope, loc. cit. 1881, p. 1019. *Mesonyx navajovius* Cope, Proceeds. Amer. Philos. Society, 1881, p. 484.

Triisodon quivirensis Cope Amer. Nat. 1881, p. 667.

Triisodon heilprinianus Cope, Proceeds. Amer Philos. Soc. 1881 (1882), p. 193.

Deltatherium fundaminis Cope, Amer. Nat. 1881, p. 237; 1881, p. 337.

Lipodectes penetrans, loc. cit. 1881, p. 1019.

Deltatherium baldwini Cope.

This Creodont is known only from a portion of a right mandibular ramus which supports the two last premolars, and the first true molar with part of the second. It differs from the *D. fundaminis* in its materially smaller size, and in the forms of the teeth. The first true molar is a more robust tooth, and the basis of the posterior or heel crest is more rounded, and less angulate. The anterior inner cusp projects less anteriorly. The fourth premolar has a distinct anterior basal lobe which is wanting in the *D. fundaminis*. Its heel is short and wide, and the posterior face of the principal cusp is flat, and there is a rudiment of an internal tubercle on its side. The second premolar is elevated and acute, has no anterior basal lobe, and has a very short wide heel, enamel slightly roughened. The animal was rather aged.

Measurements.	M.
Length of P-m. ii and iii and M. ii	.0160
Diameters M. i anteroposterior	.0058
Diameters M. i transverse	.0040
Elevation of crown of P-m. iii	.0052
Depth of mandible at M. i	.0180

From the Puerco beds of N. W. New Mexico. Dedicated to Mr. D. Baldwin, the discoverer of the Mammalian Fauna of the Puereo beds, which is one of the most important in the history of American Palæontology.

Deltatherium interruptum Cope.

The smallest species of *Deltatherium* is, like the *D. baldwini*, only represented by the anterior part of a right mandibular ramus, which supports the last premolar and the first true molar, with the bases of the other pre-

molars and part of the canine. The canine is small and the first premolar in accordance with the generic character, is wanting. The second premolar is two-rooted. The fourth has an elevated principal cusp, and a narrow heel on the inner side of the posterior base; anterior base injured. The first true molar has very little sectorial character, and resembles the corresponding tooth of a *Pelycodus*. It differs entirely from that of the *D. fundaminis* in the possession of a well marked posterior internal cusp, which is connected by a ridge with the large internal lateral cusp of the heel. The anterior cusps of opposite sides sub-equal. A weak external basal cingulum on the anterior half of the crown; no internal cingulum. Enamel of the tooth wrinkled.

Measurements.	M.
Length of premolar series	.0140
Elevation of P-m. iv	.0040
Diameters of M. i { antero posterior	.0055
Diameters of M. i { transverse	.0042
Depth of Ramus at P-m. i	.0090
" " M.	.0113

On comparison with the *D. fundaminis*, the first molar tooth has the same dimensions, but the premolars are considerably smaller. The ramus is also shallower. Found by Mr. Baldwin in the Puerco beds of Northwest New Mexico.

Didymictis haydenianus, sp. nov.

This creodont is represented by parts of the maxillary and mandibular bones of the left side, the former supporting the four, and the latter supporting the three last molars. The arrangement of the superior molars is much as in *D. protenus*, the fourth premolar being a true sectorial. The third premolar has no internal lobe, although the section of the base of the crown is narrowly triangular. It has anterior and posterior basal lobes, and a posterior lobe on the cutting edge. In the sectorial the median lobe is a good deal more produced than the posterior, though the two form together the usual blade. The anterior basal lobe is distinct; and the internal is larger and is conic. The first true molar has the anterior external base of the crown produced. Its two external cusps are conic and distinct. The internal part of the crown is rounded and supports a conic internal tubercle, which is separated from the external cones by two small concentric tubercles. The second true molar is considerably smaller, and is transverse, its external border being very oblique. It has an acute internal lobe.

The character of the species is well-marked in the inferior true molars. The first has the form seen in other species of *Didymictis*. The heel is large, and with a median basin between lateral cutting edges. The two anterior inner cusps are of equal elevation and are near together; the external is much larger. The last molar is elongate, but reduced in size. Its anterior three cusps, rudimental in other species, are here elevated, forming the triangular mass seen in the first true molar. They are not so

elevated, however, as in that tooth, and thus not so much developed as in *Oxyæna, Stypolophus*, etc. The fourth premolar has a median cutting edge on the short heel.

Measurements.	M.
Length last four superior molars	.022
" P-m. iii	.0065
" " iv	.0085
Width " "	.0050
Diameters M. i anteroposterior	.0055
Diameters M. i transverse	.0088
Diameters M. i oblique external	.0072
Diameters M. ii anteroposterior	.0027
Diameters M. ii transverse	.0055
Diameters inferior M. I anteroposterior	.007
Diameters inferior M. I transverse	.005
Diameters inferior M. II anteroposterior	.0055
Diameters inferior M. II transverse	.003
Depth of ramus at M. II, (squeezed)	.010

The peculiar characters of the last inferior molar distinguish this species from its congeners. The last superior molar is relatively smaller than in the *D. protenus*. In size this species is superior to the *D. dawkinsianus*, and is smaller than the *D. leptomylus*. It is dedicated to the distinguished geologist Dr. F. V. Hayden.

New Mexico, D. Baldwin.

TAXEOPODA.

Condylarthra.

Periptychidæ.

Periptychus rhabdodon Cope. *Catathlœus rhabdodon*, American Naturalist, 1881, 829.

Periptychus carinidens Cope, loc. cit. 1881, p. 337.

Periptychus ditrigonus Cope, sp. nov.

This rare species is known from a right mandibular ramus, which exhibits part of the symphyseal suture, with the alveoli of the molar teeth, except the first. The only well preserved crown is that of the second true molar.

The second true molar presents very peculiar characters, and the mandibular ramus is shallower and thicker than in the two other species of *Periptychus*. The former has a wide external cingulum which is not present in the other species, and there are only six cusps instead of seven. These are peculiarly arranged. The anterior three are much as in *P. rhabdodon*, the anterior being not quite so far internal as the posterior inner, close to it, and as large as the anterior external. The posterior three, are a posterior inner and posterior median as in *P. rhabdodon*, and a peculiarly placed posterior external. This is not

opposite the posterior inner, but is anterior to such a position and intermediate between the latter point, and the one occupied by the median tubercle in *P. rhabdodon*. It is as large as the anterior external tubercle. All these tubercles are conical, and not connected by angles or ridges. The posterior external cusp leaves the cingulum wide posteriorly, and its edge develops some small tubercles. There are also some small tubercles at other points on the edge of the crown, but no other cingula. The enamel is not regularly ridged as in *P. rhabdodon*, but has a rather coarse obsolete wrinkling.

Measurements.	M.
Length from P-m. ii to M ii inclusive	.052
Diameters of M. ii { anteroposterior	.011
Diameters of M. ii { transverse	.010
Depth of ramus at M. ii	.022
Width of " "	.016
Depth of " " P-m. ii	.019

From the Puerco formation of New Mexico, D. Baldwin, discoverer.

Haploconus lineatus Cope, Amer. Nat. 1882, p. 417.

Haploconus angustus Cope, Loc. cit. 1882, p. 418. *Mioclænus angustus* Cope, loc. cit. 1881, p. 831.

Haploconus xiphodon, sp. nov.

This species is represented by a mandibular ramus, and perhaps by three rami. The one on which the species rests contains five molars, the middle one of the series broken, so that its form cannot be positively ascertained. It is probable that it is the first true molar, so that the animal exhibits the last true molar not entirely protruded, and is therefore nearly adult, but there are some reasons for suspecting it to be young. Thus the last inferior molar does not exhibit more of a heel than the second usually does, and the third supposed premolar is smaller than that tooth is in the other species, having nearly the proportions of the second premolar. The teeth present may then be supposed to be the molars from the second to the sixth inclusive. But opposed to this view is the fact that the supposed third premolar has more the structure of that tooth in details, than that of the second, and the specimens accompanying, which have the temporary dentition apparently of the same species, present premolar teeth of a very different character. In any case the present specimen represents a third species of the genus, and I describe it at present as an adult.

The third premolar has a simple compressed crown, about as high as the length of its base, and without anterior basal tubercle. It has a narrow triangular posterior face which is concave, and truncated by a cingulum below; no heel proper, nor lateral cingula. The fourth premolar is an elongate tooth consisting of a compressed principal median lobe, an anterior lobe connected with it, and a heel. The latter has elevated posterior and interior borders. A rudiment of an exterior border is seen in a narrow

ridge on the external side of the posterior face of the principal lobe of the tooth.

The sides of the premolars present rather distinct ridges, as in *Peripty-chus carinidens*. The second true molar has two anterior and three posterior tubercles; the latter close together, pointed and of about equal size. Of the anterior tubercles, the external is much the larger and more elevated. It is compressed and has a curved subacute anterior edge, which extends much in front of the internal tubercle. There is no anterior inner tubercle, nor are there any cingula. The enamel of the sides of the crown presents a few vertical ridges. The last inferior molar only differs from the second, in the greater size of the median posterior lobe, which is nevertheless smaller than in the two other species of *Haploconus*.

There is a mental foramen below the posterior edge of the second inferior premolar.

Measurements.	M.
Length of last five inferior molars	.0250
" third premolar	.0050
" fourth premolar	.0066
" second true molar	.0050
Width of second true molar	.0032
Length of third true molar	.0050
Depth of ramus at P-m. iii	.0095
" " M. iii	.0130

The two rami with the temporary premolars, exhibit the last true molar enclosed in the jaw. The third and fourth premolars are much like the fourth premolar of the specimen above described, but the fourth is a little more robust than that of the latter, which is very much like the third of the deciduous series. The space occupied by the supposed first premolar of the type specimen is too short for the fourth premolar of the deciduous series, otherwise it might be supposed to have occupied that position. The two true molars resemble those of the type, excepting that the last one does not extend so far into the base of the coronoid process, and is in accordance with the position as number two in the series.

The specimens were procured by Mr. D. Baldwin in the Puerco beds of New Mexico.

Haploconus entoconus Cope, loc. cit. 1882, p. 686.

Anisonchus coniferus Cope, loc. cit. 1882, October (September), p. 832.

Anisonchus gillianus Cope. *Haploconus gillianus* Cope, loc. cit., 1882, p. 686.

Anisonchus sectorius Cope, Proc. Amer. Philos. Soc. 1881, p. 488, *Mioclaenus sectorius*, Amer. Nat. 1881, p. 831.

Hemithlæus kowalevskianus Cope, Amer. Nat. 1882, p. 832.

Hemithlæus opisthacus Cope. *Mioclænus opisthacus*, l c. 1882, p. 833.

Conoryctes comma Cope American Naturalist, 1881, p. 829.

Conoryctes crassicuspis Cope.

The posterior part of a mandibular ramus supporting the last two molar teeth indicates a second and larger species of the genus. The ramus is one-half deeper than that of the *C. comma*, and the second true molar is much larger than in that species. The last true molar is much smaller than the the penultimate, and consists of three anterior cusps and a longer heel. The former are obtuse, the external the longer, the internal equal, the anterior on the inner edge of the crown. The heel sustains a low conic tubercle.

From the Puerco beds of N. W. New Mexico.

Phenacodontidæ.

Protogonia plicifera Cope, Amer. Nat. 1882, Oct. (Sept.), p. 833.

Protogonia subquadrata Cope, Proceedings Amer. Philos. Soc. 1881, p. 492.

Phenacodus puercensis Cope, Proc. Amer. Philos. Soc. 1881, p. 492.

Phenacodus zuniënsis Cope, loc. cit. p. 492 ; loc. cit. 1881 (1882), p. 180.

Pantolambda bathmodon Cope, Amer. Nat. 1882, p. 418.

Mioclænus turgidus Cope, Amer. Nat. 1881, p. 830.

Mioclænus minimus, sp. nov.

This is one of the least mammalia of the Puerco fauna, exceeding by a little the *Hyopsodus acolytus*. It is represented by parts of two mandibles, which display all the true molars. As there are no premolars preserved, its reference to the genus *Mioclænus* is provisional only, but its true molars have the peculiar characteristics of those of the *M. turgidus*.

The two anterior cusps of the true molars are higher than the heel, and they are united together to a point above the level of the heel. The section of both those of the M. ii is round ; that of the external one of the first is cresentic ; of the inner cusp, round. The heel is wide, and supports a cusp at the posterior external angle. It is bounded posteriorly, and on the inner side by a raised ridge, which gives with the cusp, on wearing a comma-shaped surface. A transverse ridge closely appressed to the anterior cusps connects them anteriorly. In one of the specimens there is a cingulum on the external side of the second inferior molar ; on the other specimen it is wanting. Enamel smooth.

The mandibular ramus is rather deep and compressed, and displays an external ridge on the anterior border of the coronoid, which is not continued downwards.

Measurements (*No. 2*).		M.
Length of basis of true molars		.0125
Diameters M. ii	anteroposterior	.0040
	transverse	.0035
Depth of ramus at M. ii		.0073

From the Puerco beds of New Mexico. D. Baldwin.

Mioclænus subtrigonus Cope, Amer. Nat. 1881, p. 490, 491.

Mioclænus protogonioides Cope, loc. cit. 1882, Oct. (Sept.), p. 833.

Mioclænus mandibularis Cope, Amer. Nat. 1881, p. 830.

Mioclænus baldwini Cope, loc. cit. 1882, Oct. p. 833.

GENERAL REMARKS.

The preceding list of fifty-six species is doubtless sufficiently characteristic to enable us to form a pretty good idea of the Puerco fauna. Omitting six undetermined species of reptiles, we find the following peculiarities in the remaining forms. As already pointed out the three determined species of reptiles belong to a suborder, which has thus far been only found in the Laramie formation, or Cretaceous No. 6. This gives the Puerco at once a position below all the other tertiaries. The mutilate orders of mammals may be dismissed as being not likely to occur in a lacustrine formation. The orders of land Mammals are represented as follows :

Monotremata		0
Marsupialia		5
Rodentia		0
Chiroptera		0
Edentata		0
Bunotheria		15
	Tæniodonta	2
	Tillodonta	2
	Insectivora	0
	Mesodonta	2
	Lemuroidea	0
	Creodonta	9
Taxeopoda		25
	Hyracoidea	0
	Condylarthra	25
Proboscidea		0
Amblypoda		0
Diplarthra		0
Carnivora		0
Quadrumana		0
Total		45

The above list renders the peculiar facies of this fauna at once apparent. It is the only Tertiary fauna known, from which Perissodactyla are absent. The absence of Amblypoda, one of the oldest types, is unexpected. The lack of Rodentia is remarkable, and perhaps only due to failure of discovery; but if yet to be found, they must be very rare, and their absence is consistent with their small representation in the Wasatch beds above them. In the large number of Bunotheria, the Puerco agrees with the later Eocenes, but the order is here characterized by the small number of Mesodonta; and the Lemuroidea are apparently absent. An especial feature of the fauna is the presence of five undoubted species of Marsupialia of the family Plagianlacidae, which has its origin in the Jurassic

period, and extended through the Cretaceous. It is represented in the latter period in the Laramie by the genus *Meniscoëssus.**

In the absence of a number of the existing orders of placental Mammalia, the Puerco agrees with other Eocene faunæ. In the absence of all of the placental orders with convoluted cerebral hemispheres, this fauna is more primitive than any other Eocene fauna. The absence of all ungulata excepting Taxeopoda, which have the most primitive foot structure, is further evidence of its primitive character. This is further increased by the presence of the Marsupialia above mentioned. The general result is a mixture of Marsupial, and semi-marsupial forms, with half lemurs, and a great expansion of the Hyracoid type.

In more detail, the genera of Bunotheria may be compared with those of the period immediately following; viz.: The Wasatch. One genus only of the Creodonta is common to the two epochs (*Didymictis*). Five of the species remaining are much like oppossums, and may be Marsupialia. The two genera (*Deltatherium* and *Triisodon*) to which they belong, do not occur in the Wasatch. The remaining two genera, (three species) are peculiar to the Puerco, but represent a family (Mesonychidæ) which occurs throughout our Eocenes. The two species of Mesodonta belong to genera of the Wasatch, one of them at least extending into the Bridger. The genera of Tæniodonta and Tillodonta are distinct from those of any of the later Eocenes, so far as known.

Supplement on a new Meniscotherium from the Wasatch epoch.

Meniscotherium tapiacitis, sp. nov.

The species now to be described is a good deal smaller than *M. chamense*, and, *a fortiori*, than the *M. terræ rubræ*. It is known to me from the nearly entire rami of a single mandible. These support the last five molars of one side or the other, and alveoli of two others and of the canine tooth.

Two characters besides the small size, are observable in this jaw. First, the symphysis has not the shallow convex inferior outline in transverse section; but is on the contrary angular, having subvertical sides separate from a convex middle by a rounded angle. The symphysis is thus deeper than in *M. terræ rubræ*. Second, the crown of the third inferior molar tooth has partly the form of that of the second of the *M. terræ rubræ*. It is antero-posteriorly short, and has a short heel and no anterior basal lobe; the section of the principal lobe is lenticular, and profile subconic. In *M. terræ rubræ* this tooth is elongate, with well developed heel and anterior lobe. The alveolus of the canine is relatively larger than that of the *M. terræ rubræ*. The coronoid process does not rise so close to the last molar tooth, nor so steeply, as in the latter species. The posterior recurvature of the internal extremity of the anterior limb of the posterior V of the true molars is but little marked.

* American Naturalist, 1882, p 830, Sept, 28th.

Measurements.	M.
Length of true molars on base	.018
Diameters M. ii { anteroposterior	.006
Diameters M. ii { transverse	.0044
Diameters M. iii { anteroposterior	.0065
Diameters M. iii { transverse	.0038
Diameters P-m. iii { vertical	.0045
Diameters P-m. iii { arteroposterior	.004
Width of inferior face of symphysis	.008
Depth ramus at P-m. iii	.009
" " " M. iii	.0103

This species was obtained by Mr. D. Baldwin from beds of probably lowest Wasatch age, in New Mexico.

On the Systemaitc Relations of the Carnivora Fissipedia. By E. D. Cope.

(*Read before the American Philosophical Society, October 20, 1882.*)

This order embraces the clawed mammalia with transverse glenoid cavity of the squamosal bone, confluent scaphoid and lunar bones of the carpus, and well developed cerebral hemispheres. It is well distinguished from all others at present known, but such definition is likely to be invalidated by future discovery. Some of the Insectivora possess a united scapholunar bone, but the reduction of the cerebral hemispheres of such forms distinguishes them. The presence of the crucial fissure of the hemispheres is present under various modifications in all *Carnivora,* while the parietooccipital and calcarine fissures are absent.

The many types of existing carnivora fall into natural groups, which are of the grade termed family in zoölogy. But the distinction of these from each other is not easily accompanished, nor is it easy to express their relations in a satisfactory manner. The primary suborders of pinnipedia and fissipedia are easily defined. Various characters have been considered in ascertaining the taxonomy of the more numerous fissiped division. The characters of the teeth, especially the sectorials, are important, as is also the number of the digits. Turner* has added important characters derived from the foramina at the base of the skull, and the otic bulla, which Flower† has extended. Garrod‡ has pointed out the significance of the number of convolutions of the middle and posterior part of the hemispheres. I have added some characters derived from the foramina of the posterior and lateral walls of the skull.§ Mr. Turner also defines the families by the form and relations of the paroccipital process.

* Proceedings Zoological Soc., London, 1848, p. 63.
† Loc. cit., 1869, p. 5. ‡ Loc. cit., 1878, p. 377.
§ Proceedings Amer. Philosophical Society, 1880, p.

In studying the extinct carnivora of the Tertiary period, it has become necessary to examine into the above definitions, in order to determine the affinities of the numerous genera which have been discovered. To take them up in order, I begin with the foramina at the base of the skull. The result of my study of these has been, that their importance was not overrated by Mr. Turner, and that the divisions of secondary rank indicated by them are well founded. Secondly, as to the form and structure of the auditory bulla. Although the degree and form of inflation are characteristic of various groups of Carnivora, they cannot be used in a systematic sense, because like all characters of proportion merely, there is no way of expressing them in a tangible form. For, if the forms in question pass into each other, the gradations are *insensible*, and not sensible, as is the case with an organ composed of distinct parts. The same objection does not apply so much to the arrangement of the septa of the bulla. The septum is absent in the Arctoidea of Flower (*Ursidæ* of Turner), small in the Cynoidea (Flower, *Canidæ* Turner), and generally large in the Æluroidea (Flower, *Felidæ* Turner). But here occurs the serious discrepancy, that in the Hyænidæ, otherwise so nearly allied to the Felidæ, the septum of the bulla is wanting. Nevertheless, the serial arrangement of the order indicated by Flower, viz.: commencing with the Arctoidea, following with the Cynoidea, and ending with the Æluroidea, is generally sustained by the structure of the auditory bulla, and by the characters of the feet and dentition, as well as of the cranial foramina. Turner's arrangement in the order, Ursidæ, Felidæ and Canidæ, is not sustained by his own characters, and its only support is derived from Flower's observations on the external or sylvian convolution of the hemisphere of the brain.* There are three simple longitudinal convolutions in the raccoons; in the civets and cats the inferior convolution is fissured at the extremities, while in the dogs it is entirely divided, so that there are four longitudinal convolutions between the Sylvian and median fissures.

An important set of characters hitherto overlooked, confirms Flower's order. I refer to those derived from the turbinal bones. In the ursine and canine forms generally, the maxilloturbinal is largely developed, and excludes the two ethmoturbinals from the anterior nareal opening. In the Feline group, as arranged by Turner, the inferior ethmoturbinal is developed at the expense of the maxilloturbinal, and occupies a part of the anterior nareal opening. These modifications are not, so far as my experience has gone, subject to the exceptions seen in the development of the otic septa and molar teeth, while they coincide with their indications. The seals possess the character of the inferior group, or Ursidæ, in a high degree.

The characters derived from the paroccipital process are of limited application, as the study of the extinct forms shows.

* Proceedings Zoological Society, London, 1869, p. 482.

I would then divide the fissiped carnivora into two tribes as follows :

External nostril occupied by the complex maxilloturbinal bone ; ethmoturbinals confined to the posterior part of the nasal fossa ; the inferior ethmoturbinal of reduced size.....HYPOMYCTERI.
External nostril occupied by the inferior ethmoturbinal and the reduced maxilloturbinal.....EPIMYCTERI.

While no doubt transitional forms will be discovered, the types at present known fall very distinctly into one or the other of these divisions. The characters are readily preceived on looking into the nares of well cleaned specimens. The *Hypomycteri* stand next to the *Pinnipedia*, since the maxilloturbinal bone has the same anterior development in that group.

In searching for definitions of the families, it is necessary to be precise as to the definition of terms. The meaning of the word sectorial is in this connection important, since there are so many transitional forms between the sectorial and tubercular tooth. A sectorial tooth then of the upper jaw, is one which has at least two external tubercles, which are the the homologues of the median and posterior lobes of the sectorial of the cat. By the flattening and emargination of their continuous edges, the sectorial blade is formed. One or two interior, and an anterior lobe, may or may not exist. In the genera of the *Procyonidæ*, except in *Bassaris*, the two external tubercles do not form a blade. The inferior sectorial tooth differs from the tubercular only in having an anterior lobe or cusp, which belongs primitively to the interior side. The inferior sectorial teeth with large heels, as in Viverridæ and Canidæ, I have called tubercular-sectorials. The sectorial blade is formed by the union and emargination of the edges of the anterior and the principal external cusp. This blade is not well developed in the genus *Cynogale* and still less in the *Procyonidæ* and *Ursidæ*. The families are then defined as follows.

HYPOMYCTERI.

I. No sectorial teeth in either jaw.

Toes 5–5.....*Cercoleptidæ*.

II. Sectorial teeth in both jaws.

a. Toes 5–5

β. No alisphenoid canal.

True molars $\frac{2}{2}$.....*Procyonidæ*.
" " $\frac{1}{2}$.....*Mustelidæ*.

ββ. An alisphenoid canal.

Molars quadrate, $\frac{2}{2}$.....*Aeluridæ*.
Molars longitudinal, $\frac{2}{3}$.....*Ursidæ*.

aa. Toes 5–4 or 4–4.

Sectorials well developed, an alisphenoid canal.....*Canidæ*.

EPIMYCTERI.

I. Molars haplodont.

Toes 5-4; no alisphenoid canal..... .....*Protelidæ.*

II. Molars bunodont, no sectorials.

Toes 5-5; an alisphenoid canal.....*Arctictidæ.*

III. Molars bunodont, with sectorials.

a. Otic bulla with septum.

β. Alisphenoid canal and postglenoid foramen, present.

γ. True molars well developed.

Toes 5-5..... .....*Viverridæ.*

Toes 5-4.....*Cynictidæ.*

Toes 4-4.....*Suricatidæ.*

γγ. True molars much reduced.

Toes 5-5..... .....*Cryptoproctidæ.*

Toes 5-4.....*Nimravidæ.*

ββ. No alisphenoid canal; post glenoid foramen rudimental or wanting.

Toes 5-4..... .....*Felidæ.*

αα Otic bulla without septum.

No alisphenoid canal, nor post glenoid foramen: Toes 4-4.....*Hyænidæ.*

The genera of these families are the following:

CERCOLEPTIDÆ; *Cercoleptes* Neotropical.

PROCYONIDÆ; *Procyon,* Bassaricyon, Bassaris;* Nearctic and Neotropical.

MUSTELIDÆ; Melinæ (two tubercles of internal side of superior sectorial); *Taxidea, Meles.* Mustelinæ, (one internal tubercle of superior sectorials); *Enhydris, Pteronura, Lutra, Aonyx, Barangia; Helictis, Zorilla, Mephitis, Conepatus; Mellivora; Gulo, Galictis, Putorius, Mustela.*

ÆLURIDÆ; *Aelurus; Æluropodæ? Hyænarctos.*

URSIDÆ; *Helarctos; Arctotherium; Ursus; Melursus.*

CANIDÆ; *Megalotis†; Amphicyon; Thous, Paleocyon, Temnocyon, Galecynus, Canis, Vulpes, Enhydrocyon, Hyænocyon, Tomarctus, Speothus, Synagodus, Dysodus, Oligobunis, Icticyon, Lycaon.*

PROTELIDÆ; *Proteles.* Ethiopian.

ARCTICTIDÆ; *Arctictis.* Indian.

VIVERRIDÆ; *Cynogale, Arctogale, Paguma, Paradoxurus, Nandinia, Hemigale, Galidia, Prionodon, Genetta Viverricula, Viverra, Galidictis, Herpestes, Athylax, Calogale, Ichneumia, Bdeogale, Urva, Tœniogale, Onychogale, Helogale, Rhinogale, Mungos, Crossarchus, Eupleres.*

CYNICTIDÆ; *Cynictis, ? Ictitherium.*

SURICATIDÆ; *Suricata;* Ethiopia.

CRYPTOPROCTIDÆ; *Proœlurus; Cryptoprocta.*

NIMRAVIDÆ; *Archælurus, Nimravus; Ælurogale, Dinictis, Pogonodon; Hoplophoneus.*

* Including *Nasua*, which is not distinct.

† This genus cannot be made the type of a family as is done by Dr. Gray.

FELIDÆ; Machærodontinæ; *Machærodus, Smilodon;* Felinæ; *Plethælurus* (g. n.)*, *Catolynx; Felis; Neofelis; Uncia,*† *Lynx, Cynælurus.*

HYÆNIDÆ, *Hyænictis, Hyæna, Crocuta.*

* Type, *Felis planiceps* Temm. Char. Second (first) superior premolar two rooted; orbit closed behind; pupil round.

† Mr. Wortman has called my attention to a character of this genus which confirms its separation from Felis, as I proposed in 1879. The maxilloturbinal bone is less complex in the genus Uncia, than in Felis, consistently with a less nocturnal habit, and less necessity for acute smell.

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Paleontological Bulletin, No. 36.

FIRST ADDITION

TO THE

FAUNA OF THE PUERCO EOCENE.

(Read before the American Philosophical Society, January 5, 1883.)

ON THE

BRAINS

OF THE

EOCENE MAMMALIA PHENACODUS AND PERIPTYCHUS.

(Read before the American Philosophical Society, December 15, 1882.)

FOURTH CONTRIBUTION

TO THE

HISTORY OF THE PERMIAN FORMATION OF TEXAS.

(Read before the American Philosophical Society, March 16, 1883.)

By PROFESSOR E. D. COPE.

For Sale by A. E. Foote,
1223 BELMONT AVENUE, PHILADELPHIA.

First Addition to the Fauna of the Puerco Eocene. By E. D. Cope.

(*Read before the American Philosophical Society, Jan. 5, 1883.*)

There are fifty-five species included in my synopsis of the vertebrata of the Puerco epoch*. Ten of these are reptilia, the remainder mammalia. In the present paper a number of interesting additions are made. The typical specimens are figured in the fourth volume of the U. S. Geological Survey of the Territories, now in press.

OPHIDIA.

HELAGRAS PRISCIFORMIS, gen. et sp. nov.

Char. gen. The generic characters are drawn from vertebræ only. These display a modified form of the zygosphen articulation, as follows: The roof of the zygantrum is deeply notched on each side of the median line so as to expose the superior lateral angles of the zygosphen. This separate median portion of the roof of the zygantrum forms a wedge-shaped body which may be called the *episphen*. It is surmounted by a tuberosity, which constitutes the entire neural spine. The latter is thus entirely different in form from that of other serpents. Articular extremities of centrum round, the ball looking somewhat upwards. Costal articulation 8-shaped, the surfaces convex and continuous. Hypapophyses none on the two vertebræ preserved. Zygapophyses prominent. Free diapophyses none.

This genus is readily distinguished by the presence, now first observed, of the *episphen* in addition to the zygosphen; and by the peculiar form of the neural spine. We have now several vertebral articulations originally discovered in American vertebrata. These are the *episphen* as above, the *hyposphen*, which characterizes the Opisthocœlous Dinosauria (*Sauropoda* Marsh), and the *Diadectidæ* of the Permian period; and the *zygantrapophysis*, which is present in the Diplocaulid family of Batrachia.

Char. specif. A section of the vertebra at the middle is pentagonal, the inferior side slightly convex downwards. The lateral angle is the section of the angular ridge which connects the zygapophyses. The episphen has a shallow rounded groove on its infero-posterior side, which is bounded by a projecting angle on each side at its middle. The episphen does not project so far posteriorly as the postzygapophyses, and the degree of its prominence differs in different parts of the vertebral column. In one of the two vertebræ in my possession its prominence is small. The tuberosity on its summit is a truncate oval with the long diameter anteroposterior, and equaling two-fifths the length of the arch above. It is elevated above the rest of the median line, which is roof-like, with obtuse angle. The tubercular articular facet is entirely below the prezygapophyseal surface, but the free part of the prezygapophysis extends well in front of it. It is distinguished from the capitular surface by a very slight constriction. A slight ridge extends from the capitular articulation

* Paleontological Bulletin No. 35, Nov. 11th, 1882.

to the edge of the ball of the centrum. Below this the surface is slightly concave, and the middle line is gently convex. The latter terminates in an obtuse angled mark just in front of the edge of the ball. This edge is also slightly free from the ball. The capitular costal surfaces do not project inferiorly quite to the line of the inferior surface of the centrum.

Measurements of a Vertebra.	M.
Length of centrum (with ball)	.0070
Diameters of ball { vertical	.0035
Diameters of ball { transverse	.0040
Elevation of vertebra at episphen	.0085
" " middle	.0062
Width at prezygapophyses	.0120
" tubercular costal faces	.0105
" of zygantrum	.0058
Vertical diameter costal faces	.0040
Transverse diameter tubercular costal face	.0028

This snake was about the size of the black snake, *Bascanium constrictor*. It is an interesting species for two reasons. First, it is the oldest serpent known from North America. Second, in the imperfection of the zygantrum we observe an approximation to the ordinary reptilian type of vertebra, from which the ophidian type was no doubt derived. In the former there is no zygosphen or zygantrum.

Mammalia.

Triisodon levisianus, sp nov.

This creodont is represented by part of a right mandibular raums which contains the fourth premolar minus its principal cusp, and the first and second true molars, with the alveoli of the third. The ramus is deep, and probably belonged to an animal of about the size of the red fox. The molars have the structure most like that of the *T. heilprinianus*, especially anteriorly. The principal anterior cusps are united together for most of their elevation, while the anterior inner is much smaller and lower, and is situated between the middle and inner side of the anterior cusp. The heel is rather wide, and has a raised border. The external part of it is angular, and is somewhat within the vertical line of the base of the crown. The fourth premolar differs from that of the type the genus, *T. quivirensis*, in having two acute longitudinal tubercles situated close together on the heel.

The anterior masseteric ridge is very prominent. The masseteric fossa is strongly concave, but shallows gradually inferiorly. Its inferior border presents a low thickened ridge, which is recurved in front. This may be an individual character only. The inferior outline of the ramus is generally convex, and does not rise much below the masseteric fossa.

Measurements.	M.
Length of last four inferior molars	.0315
" true molars	.0230
Diameters of M. i. anteroposterior	.0085
Diameters of M. i. transverse	.0055
Length of P-m. iv. on base	.0090
Depth of ramus at M.i	.0200
Thickness " "	.0085

This *Triisodon* is not only materially smaller than the *T. heilprinianus*, but differs in the characters of the heel of the inferior molars. In that species the internal border is tubercular; in this one it is entire. The *T. conidens* and *T. quivirensis* differ in the arrangement of the anterior cusps.

Dedicated to my friend, Henry Carvill Lewis, professor of mineralogy and geology in the Academy of Natural Sciences, Philadelphia.

MIOCLÆNUS FEROX, sp. nov.

This new species is represented by three specimens. One of these includes various separate teeth and a considerable portion of the skeleton; a second includes loose teeth and a smaller number of bones of the skeleton; and the third consists of a part of a mandibular ramus, which contains the three true molars. These indicate the largest species of the genus yet known, the first individual above mentioned being about the size of a wolf.

The bones of the *Mioclænus ferox* enable me to refer the genus approximately to its proper position in the system. Although we do not possess the corresponding parts of the *Mioclænus turgidus*, the type of the genus, it is probable, if not certain, that they agree in generic characters. The agreement in dentition extends to all the principal technical points, though the specific differences are marked.

The skeleton is that of a creodont. The unequal phlanges are compressed claws, and the metapodial bones have protuberant condyles. The astragalus has a simple head with convex surface, and the trochlea is a shallow open groove.

The tubercular dentition refers this genus to the *Arctocyonidæ*.* With this family it is accordingly placed provisionally. It differs from the known fossil genera in the single tubercle of the internal part of the crown of the superior molars.

The species *M. brachystomus* and *M. etsagicus* of the Wasatch epoch must now be removed from this genus. I have shown that the former is an Artiodactyle. Now in technical points, the dentition of those species is identical with that of *Pantolestes* Cope, as well as with *Mioclænus*. Although the skeleton of the type of *Pantolestes*, *P. longicaudus* of the Bridger Beds, is yet unknown, it is safe to suppose that it does not differ from that of the *M. brachystomus*. I therefore refer the two species first mentioned to *Pantolestes*, and place that genus in the Artiodactyle sub-order.

* For the dentition of this family see Lemoine, Annales, Sc. Nat., 1878, July.

Char. specif.—The canines are well developed, and have a robust root. The crown is rather slender and is very acute. It is rounded in front, but has an acute angle posteriorly. It is not grooved, and the enamel is smooth. The single-rooted first superior premolar is situated close to the canine, and behind it is a short diastema. I have the probable first true molar or fourth premolar. The external cusps are rather small, and are well separated from each other. The inner outline of the crown is rather broadly rounded. The internal tubercle is connected on wearing, with an anterior transverse crest which terminates near the inner base of the anterior external cusp in an intermediate tubercle. There is a posterior intermediate tubercle. There is a cingulum all round the crown excepting at the posterior intermediate tubercle. The second (? first) true molar is like the one just described, but has relatively greater antero-posterior width. In this tooth the cingulum extends all the way round the crown.

There are but two inferior molars of this individual preserved, the second and third true. The former of these has a parallelogrammic outline with rounded angles. There are two posterior and two anterior rather large tubercles; an anterior transverse ledge; and a narrow external and posterior cingulum, the latter running into the internal posterior tubercle. The latter has a circular section, and is much smaller than the external posterior, which has a wide crescentic section. Of the anterior tubercles the anterior is much the larger, judging from its worn base. The third true molar is triangular in outline. Its crown includes two anterior and an external median tubercle. The inner and posterior parts of the crown form a wide shelf, with the internal edge denticulate. A weak external cingulum.

Measurements of Teeth.		M.
Diameters base of crown of incisor	anteroposterior	.0045
	transverse	.004
Diameters base crown of canine	anteroposterior	.0130
	transverse	.0095
Diameters crown, superior M. i.	anteroposterior	.0095
	transverse	.0120
Diameters, M.? ii.	anteroposterior	.0110
	transverse	.0110
Diameters of inferior M. ii	anteroposterior	.0120
	transverse	.0105
Diameters of inferior M. iii.	anteroposterior	.0125
	transverse	.0090

The second individual includes part of the superior walls of the skull. The fragment displays a high sagittal crest, which is fissured in front so as to keep the temporal ridges apart to near its anterior apex. The brain surfaces show small, smooth, flat hemispheres, separated by a constriction from the wide and large olfactory lobes. The navicular bone shows three well defined distal facets, indicating probably five digits in the pes. The teeth of this specimen include a posterior superior molar, and an inferior

third or fourth premolar, with other teeth. The premolar is like that of a creodont. Its principal cusp is a simple cone. To this is added a short wide heel, whose superior surface is in two parts, a higher and a lower, divided by a median ridge. A low anterior basal lobe, and a weak external cingulum.

The third specimen belonged to an individual a little smaller than the other two. It includes the first inferior true molar, a tooth lost from the others. Its form is somewhat narrowed anteriorly, where it has two low, but well separated anterior inner tubercles, which form a V with the external anterior.

Specimen No. 1 is accompanied by fragments of vertebræ and limbs. The former are principally from the lumbar region, but fragments of the atlas remain. This vertebra is of moderate length, and the cotylus is somewhat oblique. The vertebrarterial canal is rather elongate, and its anterior groove-like continuation in front of the diapophysis is not deeply excavated. The lumbar vertebræ are remarkable in the characters of their zygapophyses. These display subcylindric surfaces of the posterior pair, which indicates that the anterior ones are involuted, as in the specialized Artiodactyles and Perissodactyles of the later geological ages. Such a structure does not exist among carnivora, nor to my knowledge among creodonta, nor in any mammals of the Lower Eocene. I do not find it in *Didelphys* nor *Phascolarctos*, but it exists in a moderately developed degree in *Sarcophilus*. The articular surface forms more than half of a cylinder, and its superior portion is bounded within by an anteroposterior open groove. The surface within this is not revolute, as in *Bos* and *Sus*, but the articular surface disappears, as in *Cervus*. Eight such postzygapophyses are preserved, all disconnected from their centra. Two of them are united together. There are two other separated zygapophyses of smaller size, which have but slightly convex surfaces. One is probably a prezygapophysis of a dorsal vertebra. No centrum is preserved.

Of the anterior limb there is a probable distal half of a radius. It is of peculiar form, and resembles that of *Sarcophilus ursinus* more than any other species accessible to me. One peculiarity consists in the outward look of its carpal surface, which makes an angle of about 45° with the long axis of the shaft. The obliquity in *S. ursinus* is less. The external border of the shaft in *M. ferox* is, however, straight, and terminates in a depressed tuberosity. Beyond this, the border extends obliquely outward to the carpal face, which it reaches at a right angle. The internal border of the shaft is gradually curved outwards to the external border of the carpal face. Its edge is obtuse, while the external one is more acute for a short distance, and rises to the anterior (superior) plane of the shaft. The carpal face is a spherically subtriangular with rounded angles. It displays two slightly distinguished facets, one of which is superior, and the other is larger and surrounds it, except on the superior side. The internal marginal projection, or "styloid process," is not so prominent as in *S. ursinus*, and is a roughened raised margin. Joining it on the inferior edge of

the carpal face is another rough projection of the margin. Immediately opposite this, on the superior edge of the carpal face, is a rough tuberosity, which encloses a small rough fossa, between itself and the styloid process. Internal to it is a shallow groove for an extensor tendon of the manus; then a low short ridge, and internal to that a wide shallow depression for other extensors. The carpal face differs greatly from those of *Sarcophilus* and *Didelphys* in having the inner portion wider than the outer, instead of the reverse, and in having no distinct styloid process. It indicates that the manus was turned outwards much more decidedly than in those genera.

Of carpal bones the only recognizable one is the unciform. Its proximal articular surface rises with a strong convexity entad, and descends to an edge ectad. The metacarpal surface is concave in anteroposterior section, forming a wide shallow groove, extending in the direction of the width of the foot. Its two metacarpal areas are not distinguished. The entire first and second metacarpals, with the heads of the third and fourth are preserved. They considerably resemble those of *Sarcophilus ursinus*. The distal articulations are injured in both, but both display a sharp trochlear keel posteriorly, which on the second extends nearly to the superior face of the articulation. The condyle is subround, and is constricted laterally, and at the base above. The second metacarpal is short and robust, shorter than in *Sarcophilus ursinus*. The first is also robust, but is relatively longer, as it is three-quarters the length of the second. Its head is expanded, especially posteriorly, and the large trapezial face is subtriangular, with round apex directed inwards as well as forward. The posterior face of the head is notched ectad to the middle. On the external side of the head there is a vertical facet with convex distal outline, for contact with the second metacarpal. The head of the latter is narrow, and is concave between the sides. The concavity is bounded posteriorly by a raised edge. The anterior part of the proximal facet is decurved. The shaft is deep proximally, but on the distal half is wider than deep. The lateral distal fossæ are remarkably deep and narrow, the condyle very much contracted. The head of the supposed third metacarpal is as wide as the second anteriorly, but narrows to the posterior third, and then contracts abruptly to a narrow apex. The supposed external side of the head is perfectly straight, and is continuous with the side of the shaft without interruption. The entad side displays no facet, but has a depression below the head which adapts itself very well to the head of the first metacarpal. In fact, if the metacarpals just named second and third, exchange places, so that second is placed third and third second, the metacarpal series fits far better. The fourth fits the so-called second much better than the so-called third. This may therefore be the true order, although that first used agrees better with the carpus of *Sarcophilus*. The head of the so-called third is slightly convex anteroposteriorly, and is oblique laterally, descending a little to the inner side. The fourth metacarpal is wider anteriorly than either the second or third. The inner edge is straight, while

the outer is concave, the head being narrower before than behind. It has a lateral facet on each side; the inner plane, the external concave in the vertical as well as in the anteroposterior direction. It thus approaches the form of a metatarsal, but is not so strongly excavated, nor is the head notched on either side. The unciform face is convex anteroposteriorly and plane transversely.

The *femur* is broken up so that I cannot restore it. The head of the *tibia* is gone, but a considerable part of the astragalar face is preserved. This is transverse to the long axis of the tibia. It is narrowed anteroposteriorly next the fibular facet. Malleolus lost. The shaft is robust, and does not expand distally for articulation with the astragalus. Three centimeters proximal to the distal end, the external side throws out a low, rough, ridge-like tuberosity. Above the middle the crest turns outwards, leaving the internal face convex. There is a broken patella, which has one facet much wider than the other.

The *astragalus* has the trochlear portion a little oblique. That is, the internal crest is a little lower than the external, and the inner face is a little sloping. The latter is impressed by a fossa above the posterior part of the sustentacular facet, which runs out on the neck. The trochlea has a shallow groove which is nearer the external than the internal crest, and which passes entirely round the posterior aspect to the plane of the inferior face of the astragalus. The groove for the flexor tendon is thus entirely enclosed, and issues on the inferior face at the posterior extremity of the groove which separates the sustentacular from the condylar facets. The external crest of the trochlea is less prominent posteriorly than the internal, thus reversing the relations of the superior part. The internal ridge becomes quite robust, but does not flatten out and project sub-horizontally as in *Oxyæna forcipata*. The fibular face is vertical; neither its anterior nor posterior angles are produced. The neck is somewhat contracted (the internal side is injured). The head is a transverse oval, strongly convex vertically, moderately so horizontally, and without flattening. A *mesocuneïform* (or possibly *ectocuneïform*) bone is wedge-shaped in horizontal section, without posterior tuberosity, and its anterior face is a slightly oblique square. The narrower facet is oblique in the transverse sense.

The *metatarsals* are represented, excepting the first and second. The only complete one is the fifth. The heads of the third and fourth are much like those of *Oxyæna forcipata*, and of about the same size. Their anterior width is equal, and in both the external side is more oblique than the internal. Both have a notch at the middle of the internal side, but they differ in that the third has an open notch on the external side which is wanting to the fourth. The lateral excavations of the external sides are deep and rather large, and thin out the anterior external edge. The lateral facets are correspondingly large on the fourth and fifth; on the third metatarsal it is small, and a mere decurvature of the proximal surface. That of the fourth is longer proximo-distally than transversely. That of the fifth is about as long as wide, and presents more anteriorly; or, to express it

more accurately, the shaft and head present more outwardly than those of the fourth. The proximal, or cuboid facet is narrow anteroposteriorly, and is curved, the external side being concave. On the external side just distal to this facet, the head of the bone expands into a large outward-looking tuberosity, which is separated from the posterior tuberosity by a strong notch. Between it and the head proper, on the anterior face, is a large fossa. The entire form is something like that of the proximal extremity of a femur with head, neck, great trochanter and trochanteric fossa. A somewhat similar form is seen in the corresponding bone of *Oxyæna forcipata*. The shaft of the fifth metatarsal, is one-fifth longer than that of the second metacarpal (? 3d) above described. Its direction is straight, but it is somewhat curved anteroposteriorly. Its section is subtriangular, the apex external. The condyle is narrowed and sub-globular above, and spreads laterally behind, the external expansion being wide and more oblique. The keel is prominent, and is only visible from above (in front) as an angle. The distal extremities of some other metatarsals differ in being flatter at the epicondyles, and concave between them on the posterior face. The condyles are more symmetrical, and are bounded above on the anterior face by a profound transverse groove. Several *phalanges* are preserved, including part of an unguis. They are all depressed, and with well marked articular surfaces, of which the distal are well grooved, and the proximal notched below. The lateral areas of insertion of the tendons of the flexors are well marked on the edges of the posterior faces. An ungual phalange is much compressed at the base. The basal table is well marked, and has a free lateral edge. The nutritive foramen enters above the posterior extremity of this edge. No trace of basal sheath.

Measurements of No. 1.	M.
Length of atlas at anterior vertebrarterial foramen	.0165
Expanse of postzygapophyses of a lumbar vertebra	.0230
Diameter radius at middle of shaft	.0100
Greatest distal width of radius	.0220
Diameters carpal surface { vertical	.0140
Diameters carpal surface { transverse	.0185
Diameters of unciform { vertical (interiorly)	.0130
Diameters of unciform { anteroposterior (greatest)	.0140
Diameters of unciform { transverse (in front)	.0150
Diameters head metacarpal I { anteroposterior	.0130
Diameters head metacarpal I { transverse	.0120
Length of metacarpal I	.0310
Width metacarpal I at epicondyles	.0110
Diameters head metacarpal II { anteroposterior	.0110
Diameters head metacarpal II { transverse	.0070
Length of metacarpal II (or III)	.0400
Width do. at epicondyles	.0120
Diameter head of M. III (or II) { anteroposterior	.0125
Diameter head of M. III (or II) { transverse	.0075

Measurements of No. 1.	M.
Diameters head of M. IV { anteroposterior	.0120
Diameters head of M. IV { transverse (at middle)	.0070
Width of patella near middle	.0190
Diameters of tibia .07 M. from astragalus { anteroposterior	.0185
Diameters of tibia .07 M. from astragalus { transverse	.0130
Anteroposterior width of astragalar face	.0200
Total length of astragalus	.0310
Diameters of the trochlea { length on groove	.0210
Diameters of the trochlea { width above	.0160
Diameters of the trochlea { elevation externally	.0130
Greatest width of astragalus below	.0225
Length anterior to internal crest of trochlea	.0100
Diameters head of metatarsal III { anteroposterior	.0130
Diameters head of metatarsal III { transverse (in front)	.0110
Diameters head of metatarsal IV { anteroposterior	.0140
Diameters head of metatarsal IV { transverse	.0105
Diameters head M. V { without tuberosity { anteroposterior	.0120
Diameters head M. V { without tuberosity { transverse { with lateral facet	.0080
Diameters head M. V { without tuberosity { transverse { without do.	.0040
Diameters head M. V { transverse over all	.0170
Length Mt. V	.0460
Width do. at epicondyles	.0120
Width do. at condyle above	.0065
Width of M. III or IV at epicondyles	.0120
Width of proximal end of phalange	.012
Length of smaller phalange (1st series)	.0230
Proximal diameter do. { vertical	.0070
Proximal diameter do. { transverse	.0110
Ungual phalange, vertical diameter of cotylus	.0090

The specimen which has been partially described in the preceding pages as No. 2, has many pieces which are identical with those preserved in specimen No. 1. Among these may be mentioned the glenoid cavities of the squamosal bone. These display, besides the large postglenoid process, a well developed preglenoid ridge, as in *Arctocyonidæ*, *Oxyænidæ* and *Mesonychidæ*. A large distal caudal vertebra of elongate form, indicates a long tail. An articular extremity of a flat bone is intermediate in form between the proximal end of the marsupial bone of *Didelphys* and that of *Sarcophilus*. Its principal and transverse articular surface is transversely convex, as in the latter (*S. ursinus*), but the lesser articular face is separated from it by an even shorter concave interspace than in the opossum. It has almost exactly the form of that of the latter animal. It is a short, flat cone, with two faces presenting on the same side, the one part of the concavity mentioned, the other flat and presenting away from it. This

piece has a slight resemblance to the very peculiar head of the fibula in the oppossum, but is not like that of *Sarcophilus ursinus*. I, however, think it much more probably the proximal extremity of a marsupial bone.

A supposed *cuneïform* is subtransverse in position, and resembles in general those of *Oxyæna* and *Esthonyx*. It has the two large transverse proximal facets, the anterior one-quarter wider than the posterior. The distal facet (trapeziotrapezoidal) is simple. The *navicular* is much like that of *Oxyæna forcipata*, but is more robust. Its external tuberosity is flattened anteroposteriorly, and is produced proximally. The three distal facets are well marked, the median a little wider than the external, while the internal is subround, convex, and sublateral in position. The *entocuneïform* is a flat bone, with cup-shaped facet for the navicular, and narrow facet for the first metatarsus. This facet is transverse transversely, and concave anteroposteriorly. It shows (1), that there is a pollex; (2), that it is probably small; and (3), that it was not opposable to the other digits, as is the case in the opossum. (4). It does not show whether the pollex has an unguis or not.

Measurements No. 2.	M.
Transverse width condyle of mandible	.0230
Anteroposterior width condyle of mandible (at middle)	.0103
Diameters head of *os marsupii*: transverse	.0220
Diameters head of *os marsupii*: anteroposterior	.0068
Diameters cuneïform: vertical	.0075
Diameters cuneïform: anteroposterior	.0115
Diameters navicular: vertical in front	.0085
Diameters navicular: transverse	.0180
Diameters navicular: anteroposterior (middle)	.0110
Diameters ectocuneïform: vertical at middle	.0100
Diameters ectocuneïform: anteroposterior (middle)	.0140
Diameters ectocuneïform: transverse distally	.0060

Two other bones of specimen No. 2 I cannot positively determine. The first resembles somewhat the trapezium of *Sarcophilus ursinus*, and still more that of *Didelphys*. I will figure it, as a description without identification will be incomprehensible. The next bone is of very anomalous form. It may be the magnum, which is the only unrecognized bone of importance remaining, or it may be a large intermedium. It has no resemblance to the magnum of any mammal known to me. It was evidently wedged between several bones, as it has eight articular facets. Two are on one side; the largest (convex and oval) is on one edge; three are on one end, and two, the least marked, are on the other flat side, opposite to the first.

Restoration. We can now read the nature of the primitive mammal *Mioclænus ferox*, in so far as the materials above discussed permit. It was a powerful flesh-eater, and probably an eater of other things than flesh. It had a long tail and well-developed limbs. It had five toes all around, and the great or first toe was not opposable to the others, and may have been

rudimental. The feet were plantigrade and the claws prehensile. The fore feet were well turned outwards. There were in all probability marsupial bones, but whether there was a pouch or not cannot be determined. These points, in connection with the absence of inflection of the angle of the lower jaw, render it probable that the nearest living ally of the *Mioclænus ferox* is the *Thylacynus cynocephalus* of Tasmania. The presence of a patella distinguishes it from Marsupials in general. Its dentition, glenoid cavity of the skull and other characters, place it near the *Arctocyonidæ*. Should the forms included in that family be found to possess marsupial bones, they must probably be removed from the *Creodonta* and placed in the *Marsupialia*.

This species is about the size of a sheep. The bones are stated by Mr. Baldwin, who discovered it, to be derived from the red beds in the upper part of the Puerco series.

MIOCLÆNUS BUCCULENTUS, sp. nov.

A part of the right maxillary bone which supports three molars indicates this species. The molars are P-m iv, M. i and M. ii. This series is characterized by the remarkably small size of the fourth premolar, and large size of the second true molar. The first true molar is intermediate.

The fourth premolar consists of an external cone and a much smaller internal one. There is a weak posterior basal cingulum. The reduced size of the internal cone suggests the probability that the third premolar has no internal cusp, and that there may be but three premolars. In either case the species must be distinguished from *Mioclænus*.

The first and second true molars have conic well separated external cusps, and a single pyramidal internal cusp. The intermediate tubercles are distinct. There is a posterior cingulum which terminates interiorly in a flat prominence. There is an anterior cingulum and a strong external one, which form a prominence at the anterior external angle of the crown. Enamel wrinkled.

Measurements of Superior Molars.		M.
Length of bases of P-m. iv M. i and ii		.0180
Diameters P-m. iv	anteroposterior	.0040
	transverse	.0046
Diameters of M. i	anteroposterior	.0060
	transverse	.0065
Diameter of M. ii	anteroposterior	.0070
	transverse	.0085

MIOCLÆNUS SUBTRIGONUS Cope.

This species has been known hitherto* from a palate with three molars. I am now able to give the characters of the inferior molar series, which have been found, by Mr. Baldwin, associated with the true superior molars. Of the latter it may be remarked that the second true molar is not so much

*American Naturalist, 1881, 490-1.

longer than the first as in *M. bucculentus*, although the difference in size is very evident. The third is smaller than the first, and ovoid in outline, while the first and second are subquadrate. The external cusps are conic and widely separated and the intermediate areas are distinct. There is a cingulum all round the crown of the last two, and round that of the first except at the inner side, and at the anteroëxternal angle.

The last three inferior premolars are higher than long at the base, and are compressed and the apex acute. The posterior edge of the third and fourth is truncate, and simple. Each has a posterior cingulum which forms a narrow heel on the fourth. No other cingula. Of the true molars only the second is wanting. The form of these is like those of the *M. ferox*, with the cusps more prominent. The first only has trace of the anterior V; in the others, the two anterior tubercles are opposite and connected by a short anterior ledge. The heel of the first consists of a basin bounded by these tubercles, of which the external is pyramidal and largest. The median posterior is small. The heel of the third is narrow and prominent, and the internal lateral tubercle is represented by a short raised edge. The enamel of all the molars is wrinkled, and the inner side of the premolars is grooved with the height of the crown. A weak external cingulum on M. iii.

Measurements.	M.
Length of last three superior molars	.0265
Diameters of M. i { anteroposterior	.0060
Diameters of M. i { transverse	.0060
Diameters of M. ii { anteroposterior	.0062
Diameters of M. ii { transverse	.0072
Diameters of M. iii { anteroposterior	.0047
Diameters of M. iii { transverse	.0060
Length of last inferior molars	.0340
Length of last three premolars	.0140
Length of P-m. iv	.0050
Elevation of P-m. iv	.0050
Diameters of M. i { anteroposterior	.0057
Diameters of M. i { transverse	.0042
Diameters of M. iii { anteroposterior	.0070
Diameters of M. iii { transverse	.0035

Rather larger than the pine weasel, *Mustela americana*.

MIOCLÆNUS CORRUGATUS, sp. nov.

This species is known from a right maxillary bone which contains the last four molar teeth, with parts of pelvis and other bones of one individual.

This species is intermediate in size between the *M. protogonioides* and *M. ferox*, as the following measurements of the second superior true molar show:

	M. protogonioides.	*M. corrugatus.*	*M. ferox.*
Diameter, transverse	.011	.0118	.015
" anteroposterior	.008	.010	.013

The superior molars are more nearly quadrate than in the other species of the genus, owing to the better development of the posterior internal tubercle, which is, however, as in the others, a mere thickening of the posterior cingulum. It is wanting from the last superior molar. The cusps on the true molars are as in the *M. ferox*, small, and not large and closely placed as in *M. protogonioides*. The intermediate ones are nearly obsolete. The crowns are all entirely surrounded by a cingulum. The entire enamel surfaces wrinkled so as to be rugose, although the teeth are those of an adult and well used. The second superior molar is larger than the first, exceeding it in the transverse rather than the fore-and-aft diameter. The third is the smallest, and is of oval form with obliquely truncate external face. It is less reduced than in the *M. turgidus*.

The fourth premolar consists of a strong compressed-conic cusp with three basal cusps of small size, viz., an anterior, a posterior, and an internal. The last is the larger, though small, is formed like a heel, and is connected with the others by a cingulum. No external cingulum.

Measurements.		M.
Length of last four molars		.036
Diameters P-m. iv	anteroposterior	.010
	transverse	.008
" M. i	anteroposterior	.010
	transverse	.010
" M. iii	anteroposterior	.008
	transverse	.011

From the Upper Puerco beds.

PANTOLAMBDA BATHMODON Cope, American Naturalist, 1882, p. 418.

In describing this genus and species, I remarked, loc. cit., that they were "founded on a mandibular ramus, which supports the first true molar, and the last two premolars. The characters of these teeth remarkably resemble those of *Coryphodon*. * * * It will be for additional material to demonstrate whether this genus belongs to the *Amblypoda* or *Perissodactyla*."

A considerable part of the skeleton of this species having been recently sent me by Mr. D. Baldwin, I am able to throw much light on the affinities of this curious genus.

In the first place, the phalanges (not ungual), show that the genus is ungulate. Secondly, the astragalus has a large distal facet for the cuboid bone. This proves that the genus cannot be referred to the Taxeopod order. The question as to whether it belongs to the *Amblypoda* or the *Diplarthra* would be decided by the carpus, but that part is unfortunately not preserved, and I have to rely on empirical indications for a provisional determination. Apart from the astragalus, the characters are those of the *Condylarthra* rather than of the *Perissodactyla*, and it is therefore to be supposed that the carpus has also the characters of that order. This would

place the genus in the *Pantodonta*, which has the carpus nearly that of the *Taxeopoda*, and the tarsus of the *Diplarthra*. The points of resemblance to the *Condylarthra* are the following: The ilium is narrow. The humerus has an epitrochlear canal. The superior molar teeth have but one internal lobe. The resemblances to the *Pantodonta* are these: The cervical vertebræ are plane and short. The femur has a third trochanter. The premaxillary bone in dentigerous. The astragalar trochlea is as in the *Periptychidæ*, and the *Proboscidia;* that is without groove, and slightly convex anteroposteriorly, thus differing from that of the *Pantodonta*. The dentition is especially like that of the *Amblypoda* in general, and that of the superior series is unlike anything known in the *Diplarthra*.

I propose to place this genus in the *Amblypoda* for the present, next to the *Pantodonta*, but it cannot enter that sub-order on account of the form of its astragalus. The sub-orders of *Amblypoda* will be defined as follows:

Astragalus with a head distinct from trochlea, with distal articular facets.....*Taligrada*.
Astragalus without head; distal facets subinferior.....*Pantodonta*.

In the sub-order *Taligrada*, the single family *Pantolambdidæ* presents the following characters:

Superior and inferior molars with the cusps developed into Vs. Postglenoid process present; postympanic and paroccipital not distinct. All the vertebræ with plain articulations. Humeral condyles without intertrochlear ridge. Femur with third trochanter. Digits of posterior foot probably five. Metapodial keels small and posterior.

Of this family *Puntolambda* is as yet the only known genus. Its leading characters are as follows:

Canine teeth distinct; dental series continuous. Superior molars all triangular, that is with a single internal cusp. External cusps of premolars unknown; of molars two. Internal cusp V-shaped, sending its horns externally as cingula to the anterior and posterior bases of the external side of the crown, without intermediate tubercles. Inferior true molars with a crown of two Vs, the anterior the more elevated. Premolars consisting of one open V, with a short crest on a short heel, as in *Coryphodon*. Dental formula $I^{?}_{\frac{3}{3}}$; C. $\frac{1}{1}$; P-m. $\frac{?}{?}$; M. $\frac{3}{3}$; the last inferior with a heel. A strong sagittal crest. Auricular meatus widely open below. Large postparietal, postsquamosal and mastoid foramina.

Cervical vertebræ rather short; other vertebræ moderate, the lumbars not elongate. A large tail. Humerus with large internal epicondyle. Femur with all the trochanters large. Ilium with the anterior inferior spine well developed. Metacarpals short, plantigrade. Phalanges of second series flat, and of subquadrate outline. The astragalus has a wide head, but no neck, as it is not separated from the tochlear portion by a constriction. It is as wide as the trochlear portion, but about one-third of its length extends within the line of the malleolar face of the trochlear portion. The

navicular face is flat, that of the cuboid bone is convex vertically, and one-half as long horizontally as the navicular, and only half as deep. These two facets are continuous with the sustentacular below. Interior to all of these, on the internal tuberosity of the head is a sub-round facet looking inwards, like that characteristic of the genus *Bathmodon*, but relatively larger. A continuous facet is seen on the adjacent edge of the navicular. The use of these facets is unknown.

The brain case indicates small and nearly smooth hemispheres, extending with little contraction into a rather large cerebellum. The olfactory lobes are produced anteriorly at the extremity of a rather long isthmus.

If we consider the dentition alone, *Pantolambda* is the ancestor of the *Coryphodontidæ*. The history of the feet requires further elucidation.

The *Pantolambda bathmodon* is about as large as a sheep.

From the upper beds of the Puerco.

MIXODECTES PUNGENS, gen. et sp. nov.

Char. Gen.—The position of this genus is uncertain, but may be near to *Cynodontomys* Cope, which I have provisionally placed among the Prosimiæ*. It is only known from mandibles, which have presumably the following dental formula. I. 0 ; C. 1 ; P-m. 4 ; M. 3. An uncertainty exists as to the proper names of the anterior teeth, which cannot be decided until the discovery of the superior series. For instance the formula may be ; I. 1 ; C. 1 ; P-m. 3.

The supposed canine is a large tooth, issuing from the ramus at the symphysis like a rodent incisor, and has an oval section, with long diameter parallel to the symphysis. The crown is lost from all the specimens. The second tooth is similar in form to the first, but is much smaller. It is situated posterior and external to the first. The next tooth is still smaller and is one-rooted. The third and fourth premolars have simple conic crowns, and more or less developed heels without cusps. The true molars are in general like those of *Pelycodus ; i. e.*, with an anterior smaller, and a posterior triangle or V. The supplementary anterior inner cusp is quite small, while the principal anterior inner is elevated. The posterior inner is much more elevated than in the species of *Pelycodus*. Last inferior molar with a fifth lobe.

This genus cannot be referred to its place without additional material, but the parts discovered indicate it to be between *Pelycodus* and *Cynodontomys ;* either in the *Mesodonta* or the *Prosimiæ*. I may here remark that in defining the latter genus I was in doubt as to the number of the inferior premolars. The discovery of the present genus renders it probable that it has three such teeth, and that the anterior two are each one-rooted.

Char. Specif. The mandible of the *Mixodectes pungens* is about the size of that of the mink. Its inferior outline is straight to below the second premolar, whence it rises upwards and forwards like that of a rodent. The anterior masseteric ridge is very prominent, but terminates below the

* Paleontological Bulletin No. 34, p. 151.

middle of the ramus. Inferior masseteric ridge much less pronounced. The inferior part of the ramus is robust below the base of the coronoid process, but there is no indication of recurvature of the edge. Mental foramina two; one below the front of the first true molar, and one below the second premolar.

The oval base of the canine is not flattened on either side; that of the second tooth is flattened on the inner side. There is a great difference between the sizes of the last three premolars. The fourth is twice as large as the third, and the second, judging from the space and the size of its alveolus, was much smaller than the third, and the crown was probably a simple acute cone. The crown of the third is of that form, with the addition of a short heel. The long axis of the base of the crown is diagonal to that of the jaw. The fourth premolar has a relatively larger heel than the third, but it is shorter than the diameter of the base of the cusp. Its posterior edge is elevated. The cusps of the anterior pair of the true molars are elevated, but the interior is the most so. The supplementary one is not exactly in the line of the interior border of the crown. Each of the inner cusps are connected with the base of the external by a ridge, which together form a V. The posterior base is nearly surrounded by a raised edge, which rises into cusps at the posterior lateral angles. Of these the internal is the more prominent. The edge connecting these cusps is slightly convex backwards, and evidently bears a part in mastication. The lateral borders of the last molar are somewhat expanded, and the fifth lobe is very short. No cingula on any of the teeth.

Measurements.	M.
Length of dental series from "canine" exclusive	.0265
" true molar series	.0140
Diameters "canine" longtitudinal	.0040
Diameters "canine" transverse	.0030
Long diameter of base of "P-m. i"	.0028
" " " P. m-ii	.0017
Diameters P-m. iv vertical	.0055
Diameters P-m. iv anteroposterior	.0050
Diameters M. ii transverse	.0038
Diameters M. ii anteroposterior	.0050
Length of crown of M. iii	.0060
Depth of ramus at P-m. iii	.0090
" " M. iii	.0100

MIXODECTES CRASSIUSCULUS, sp. nov.

This mammal is represented by fragments of two mandibles from different individuals; one less and the other more worn by mastication. The species differs from the last in its greater size, and in the relatively greater length of the last inferior molar. The length of the posterior four molars of the *M. pungens* equals that of the three true molars of the *M. crassius-*

culus; and the last true molar of the latter is half as long again as the penultimate, while in *M. pungens* it exceeds it but little.

The best preserved true molar is the second. Its most elevated cusps are the anterior and posterior inner, of which the anterior is subconic and more elevated. The anterior external cusp is crescentic in section, and sends crests to the supplementary, anterior, inner and the posterior anterior inner, both of which descend inwards. The posterior crest reaches the posterior base of the anterior inner cusp.

The posterior external cusp is an elevated angle, sending crests forward and backwards. The former reaches the base of the anterior external cusp (not reaching the inner), while the latter passes round the posterior edge of the crown. As in *M. pungens*, it is convex posteriorly, and rises to the posterior internal cusp. In both species its appearance indicates that it performs an important masticatory function in connection with the superior molar. No cingula.

Measurements.	M.
Length of bases of M. ii and iii; (No. 2)	.0125
" base of M. iii; (No. 2)	.0070
Diameters crown M. ii; (No. 1) anteroposterior	.0056
Diameters crown M. ii; (No. 1) transverse	.0050
Depth of ramus at M. ii; (No. 1)	.0100

PERIPTYCHUS CARINIDENS Cope.

Additional specimens of this species demonstrate that the last inferior molar has a different form from that of the *P. rhabdodon*. While of the same length, it is narrower throughout, conformably with the smaller size of all the other molar teeth.

PHENACODUS CALCEOLATUS, sp. nov.

This species is founded on fragments of the skull and limbs, with teeth, of a single individual. The teeth consist of two superior and four inferior molars of one side, and a smaller number of those of the opposite side.

The teeth are of the size of those of the *Phenacodus puercensis*, and like that species, there is no median external cingular cusp of the superior molars. In these teeth the external basal cingulum is weak, but there is a strong anterior cingulum, distinct from any of the cusps. No internal cingulum. External cusps conical, well separated; intermediate cusps rather large; internal cusps rather large, close together, but deeply separated. The last superior molar is reduced in size. It has well developed anterior and posterior cingula, a weak external, and no internal cingula. The intermediate tubercles are rather large, and there is one large internal tubercle.

The heel of the last inferior molar is short, wide and rounded. The posterior tubercle is but little behind, opposite the posterior internal tubercle. The latter is separated from the anterior inner by a deep fissure, while the opposite side of the crown is occupied by a large median exter-

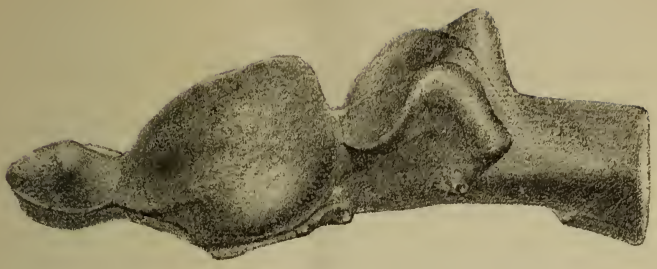
nal cusp, which has a semicircular section. The large anterior cusps are confluent on wearing. No anterior cingulum in the worn crown. The crowns of the first and second true molars of the specimen are rather worn. They show that the posterior median tubercle is very indistinct and probably absent. The bases of the smaller inner cusps are round, and on wearing unite with the larger external cusps. Of the latter the posterior is the larger. Anterior cingulum rudimental or wanting. No lateral or posterior cingula. The principal peculiarity of the lower dentition of this species and the one from which it is named, is the form of the third or fourth (probably third) premolars, both of which are preserved. They have a compressed apex, which descends steeply to the anterior base, without basal or lateral tubercle. The base of the crown spreads out laterally behind, and is broadly rounded at the posterior margin, so as to resemble the toe of a wide and moccasined foot. It is depressed, the surface rising to the apex from a flat base.

Measurements.		M.
Diameters of second superior molar	anteroposterior..	.0080
	transverse.....	.0100
Diameters of last superior molar	anteroposterior.....	.0067
	transverse.....	.0085
Length of inferior true molars.....		.0258
Diameters of M. ii	anteroposterior.....	.009
	transverse.....	.008
Diameters of M. iii	anteroposterior.....	.0085
	transverse	.0068
Diameters of the P-m. iii	anteroposterior.....	.008
	transverse.....	.005

About the size of the *P. puercensis.*

Note on the Mammalia of the Puerco and the Origin of the quadrituberculate Superior Molar.—It is now apparent that the type of superior molar tooth which predominated during the Puerco epoch was triangular; that is, with two external, and one internal tubercles. Thus of forty-one species of Mammalia of which the superior molars are known, all but four have three tubercles of the crown, and of these thirty-eight triangular ones we may except those of three species of *Periptychus*, which have a small supplementary lobe on each side of the median principal inner tubercle.

This fact is important as indicating the mode of development of the various types of superior molar teeth, on which we have not heretofore had clear light. In the first place, this type of molar exists to-day only in the insectivorous and carnivorous Marsupialia; in the Insectivora, and the tubercular molars of such Carnivora as possess them (excepting the plantigrades). In the Ungulates the only traces of it are to be found in the molars of the *Coryphodontidæ* of the Wasatch, and *Dinocerata* of the



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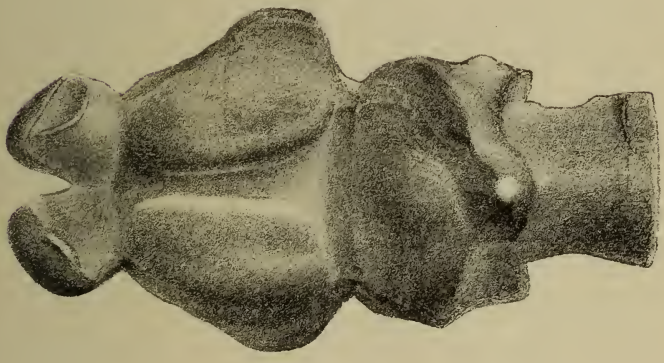

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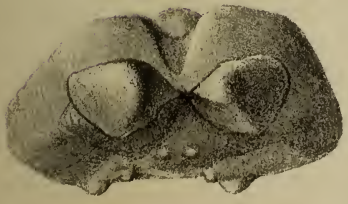

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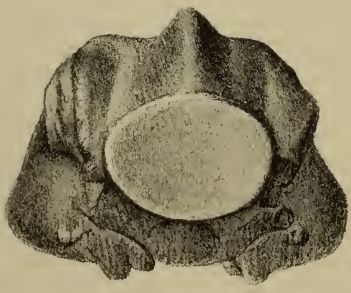

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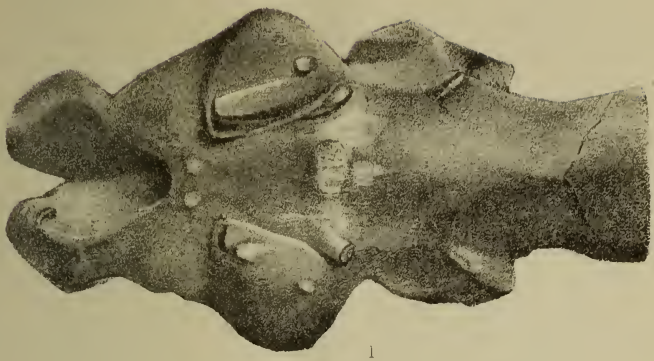
T. Sinclair & Son, Lith Phila.

PHENACODUS PRIMAEVUS ½



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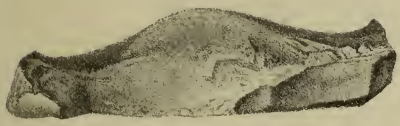

3

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T. Sinclair & S

1. PHENACODUS PRIMAEVUS ¼. 2-3. PERIPTYCH
RHABDODON ½

Bridger Eocenes. In later epochs it is chiefly seen only in the last superior molar.

It is also evident that the quadritubercular molar is derived from the tritubercular by the addition of a lobe of the inner part of a cingulum of the posterior base of the crown. Transitional states are seen in some of the *Periptychidæ* (*Anisonchus*) and in the sectorials of the *Procyonidæ*.

On the Brains of the Eocene Mammalia Phenacodus and Periptychus. By E. D. Cope.

(*Read before the American Philosophical Society, December 15, 1882.*)

PHENACODUS PRIMÆVUS Cope.

A cast of the cranial cavity gives the following as the general characters of the brain. The cerebal hemispheres are remarkably small, each one being less by one-quarter than the cerebellum. They are separated from the latter and from the large olfactory lobes by strong constrictions. The posterior one is occupied by a thick tentorium. In like manner a wide groove for a robust falx separates the hemispheres above, a notch represents the sylvian fissure, and the lobus hippocampi is quite large. The vermis of the cerebellum is quite distinct, and the lateral lobes are large. They are impressed laterally by the petrous bones as in various ruminants. The anterior columns of the medulla are not visible. There are traces of the convolutions on their hemispheres.

The brain displays the following more special features. The olfactory lobes are as wide as long, and they diverge, having two external sides. In section they are triangular, presenting an angle downwards. The hemispheres are depressed, and wider posteriorly. They are well separated from each other and from the cerebellum; so much so that it is quite probable that the copora quadrigemina are exposed. Their outlines are, however not distinguishable on the flat surface which connects the hemispheres posteriorly. No further indication of sylvian fissure can be seen in the cast beyond an entering angle defining the lobus hippocampi anteriorly. The latter is prominent externally, and less so downwards. There are distinct indications of convolutions. There are three on each side above the sylvian convolution, and a fourth extends from the sylvian upwards and posteriorly below the posterior part of the third or external convolution. The sulci separating the convolutions are very shallow. The internal and external convolutions unite anteriorly, passing round the extremity of the median convolution. The space between this gyrus and the base of the olfactory lobe is only three millimeters.

The cerebellum is larger than a single hemisphere. Its superior surface is somewhat flattened, and descends forwards; the lateral boundary of this face is a projecting edge which rises behind to an angle of the vermis. The posterior face is shorter than the superior, and is vertical. It is separated by a space from a very prominent lateral convolution, while the region of the flocculus is concave from the internal form of the ascending portion of the petrous bone. This concavity is open anteriorly. The base of the fifth pair of nerves is below its apex, and that of the sixth below the inferior extremity of the lateral convolution. The section of the medulla oblongata is a transverse oval; its inferior face and that of the pons varolii, smooth. A deep fossa just anterior to the bases of the optic nerves.

Measurements of brain.	M.
Length from vermis to olfactory lobes inclusive	.070
" of olfactory lobes from above	.015
" of hemispheres, from above	.030
" of cerebellum from above	.024
Depth of olfactory lobe	.010
" of hemisphere	.023
" of cerebellum and medulla	.026
" of medulla at vermis	.015
Width of olfactory lobes at middle	.030
" of hemispheres in front	.044
" " behind	.044
" of cerebellum	.036
" medulla at vermis	.020

PERIPTYCHUS RHABDODON Cope.

I have obtained a cast of the top and sides of the cerebral hemispheres, and the proximal portion of the olfactory lobes, from a skull of a *Periptychus* in which the teeth are preserved, and prove the species to be the *P. rhabdodon*. The olfactory lobes are enormous, and the hemispheres small and very flat. The *mesencephalon is entirely exposed.* The cerebral hemispheres are very flat, and are only differentiated from the olfactory lobes, by a moderate contraction and depression, which forms the peduncle of the latter. Only the proximal part of the olfactory lobes is preserved, but this expands so as to be only a little narrower than the hemispheres. The peduncle has a ridge on the median line, and a shallow fossa on each side of it. The lateral outlines of the hemispheres diverge, and the widest part is posterior. There is no indication of sylvian fissure. The transverse section of the hemispheres would be a flat arch, but for the presence of a longitudinal oval protuberance on each of them, which do not quite touch the median line, and which have definite boundaries. If their limits determine the size of the cerebral hemispheres, then the latter are wider

than long, but they probably pass gradually into the mesencephalon behind them. These bodies remind one of the corpora olivæformia, and may represent the superior or median frontal convolutions. They are probably, however, not to be homologized with any convolutions, representing rather the cerebral vault of the lateral ventricle. Posterior to them the flat surface descends gently without indication of copora quadrigemina or other irregularity, and at a distance about equal to the length of the oval bodies, it begins to rise gently. The cranium is broken here, and no cast of the cerebellum was obtained.

I may remark that the cranium from which this cast is taken is not crushed, and that it consists of parts of the parietal and squamosal bones only. The latter remain as far as the incurvature to the pterygoid processes in front of the glenoid cavity.

Measurements of brain.	M.
Length from posterior rise to base of olfactory lobes....	.037
Length of oval bodies of hemispheres.....	.018
Width of proximal part of olfactory lobes.....	.027
Width of olfactory peduncles.....	.021
Length from olfactory lobes to oval bodies of hemispheres.....	.005
Diameter of hemispheres at posterior part of oval bodies.	.038
Depth from sagittal crest to olfactory lobes.....	.024

EXPLANATION OF PLATES.

Plate I.

Casts of the brain case of *Phenacodus primævus* Cope, natural size.

Fig. 1. Lateral view.
Fig. 2. Superior view.
Fig. 3. Anterior view.
Fig. 4. Posterior view.

Plate II.

Fig. 1. Brain of *Phenacodus primævus*, inferior view.
Fig. 2. Cast of brain case of *Periptychus rhabdodon*, superior view.
Fig. 3. Cast of brain case of *Periptychus rhabdodon*, lateral view.

*Fourth Contribution to the History of the Permian Formation of Texas. By E. D. Cope.**

(*Read before the American Philosophical Society, March 16, 1883.*)

PISCES.

ECTOSTEORHACHIS CICERONIUS, sp. nov.

The genus *Ectosteorhachis* Cope, is known up to the present time from ichthyolites, which do not exhibit the interior details of the structure of the skull. Several portions of crania having recently come into my hands, I am able to add some important features, and a new species, which I name as above.

The base of the skull consists of ossified parachordals, which embrace the chorda dorsalis posteriorly and are continued for a short distance posteriorly as a tube. Anteriorly the chordal groove is open. Trabeculæ not ossified. The cranial structure is an excellent illustration of a permanent embryonic type. Above and in front of the opening for the chorda, the neural canal enters the groove. The parachordals are subtriangular, presenting one angle forwards, and having the internal side that bounds the groove straight and longitudinally grooved. The anteroexternal side is oblique and nearly straight, and is overhung by the osseous roof of the skull. These characters are identical in both species.

The *E. ciceronius* differs from the *E. nitidus* in having a narrower interorbital region, and in the possession of small tubercles of ganoïne on the posterior parts of the superior surface of the skull. These are seen on the sides of the surface, and are quite small, not numerous, and

*The third contribution can be found at page 447 Proceedings of the Society for 1882.

of various sizes and shapes. They resemble shining seeds. In *E. nitidus* these points are wanting, but there are rugosities on the postfrontal and pterotic regions of a radiating character, not found in *E. ciceronius*.

Measurements.	M.
No. 1.	
Length of skull to occiput above (muzzle worn)	.069
Interorbital width	.014
No. 2.	
Length of osseous base of cranium (parachordal)	.039
" open median groove	.022
Width of base at parachordals	.036
" groove at apices of parachordals	.011
" foramen notochordæ	.0095

Found by Mr. W. F. Cummins.

GNATHORHIZA SERRATA, gen. et sp. nov.

This presumed fish is represented by some teeth which are processes of osseous bodies, which may be roots properly so called, or may be jaws. The osseous bases are shallow, and thickened on the free edge, which is directed obliquely away from the plane of the crown of the teeth. The teeth obtained are flat, and doubtless bilaterally symmetrical, though no complete pairs are preserved. The largest of these has a curved edge, and a branch extending posteriorly at right angles to it, joining it at a point at one side of its middle. The longer (and more curved) part of the convex edge, has two coarse angles; the shorter part is finely denticulated, as is the transverse lamina. The principal edge is worn posteriorly by use. The external convex face is marked by coarse and finer lines of growth, like those on corneous processes. A second form of tooth is not curved, but flat, so far as preserved. It has three coarse obtuse teeth. Two other toothed bodies resemble it. All the teeth are covered with brilliant ganoïne on both sides.

Measurements.	M.
Length of chord of larger tooth	.010
" cross lamina	.0055
Elevation of principal edge	.006
" with root	.008
Thickness of root at base	.002

The genus *Gnathorhiza* may belong to the Petalodont family, though I think it very doubtful. The characters of the roots of the teeth are more like those of sharks.

BATRACHIA.

TRIMERORHACHIS BILOBATUS, sp. nov.

Among the many specimens of animals of this genus which have passed through my hands, I have not until now been able to select more than one

species, the *T. insignis*. Mr. Cummins, however, now sends me parts of skeletons of four individuals, which present distinctive characters. Two of these include vertebral elements, and all embrace jaws and bones of the limbs and arches.

The vertebræ present no important difference from those of *T. insignis*, but the surface of the intercentrum is not yet cleaned of a thin layer of matrix. The peculiar character of this species is most readily seen in the posterior portions of the mandibular ramus. The angle consists of two subequal tuberosities which are separated by a deep groove; instead of one prominent one. The external tuberosity is represented in the *T. insignis* by a small protuberance of the lateral enlargement of the external face of the ramus. The extremity of this tuberosity is in the *T. bilobatus* strongly honeycombed, and it is bounded below and externally by a groove which is faintly indicated in *T. insignis*. Above it, on the inner side, is another, shallow groove, from which it is separated by a sharp ridge. Both grooves are smooth. The superior one is wanting in *T. insignis*. The quadrate cotylus is more depressed externally than in *T. insignis*, thus making it more oblique. The internal fossa of the cotylus is not divided by a longitudinal groove, as it is in *T. insignis* The dental foramen is large, and is located as in the *T. insignis*. There is also an inferior longitudinal groove of the ramus as in that species. The surfaces preserved show that the sculpture is more marked in the *T. bilobatus* than in the *T. insignis*.

Measurements.	M.
Depth of ramus at interior edge cotylus	.026
Length " from " " "	.020
Width " at " " "	.017
" of both tuberosities of angle	.0125
Diameters of intercentrum { anteroposterior	.011
Diameters of intercentrum { transverse	.021
Thickness of intercentrum	.004

The specimens described came from the same locality, and a different one from that which has produced the specimens of the *T. insignis* (Type No. 39, 1882).

REPTILIA.

PARIOTICHUS MEGALOPS, sp. nov.

This reptile is known to me from a nearly complete, somewhat distorted cranium. A thin layer of matrix conceals the greater number of the teeth, so that the presence of canines cannot be demonstrated. Those which are visible are on the premaxillary and anterior parts of the maxillary bones. They are small, conic, slightly curved, acute and absolutely smooth.

The muzzle is short and broadly rounded. The nareal opening is laterosuperior, and is just above the principal convexity where the lores pass into the muzzle. Canthus nostralis rounded off. Interorbital region wide, convex in section, nearly plane anteroposteriorly, its width a little exceeding the diameter of the orbit. Orbit large and round, its diameter equal to

the length of the muzzle in front of it, obliquely measured, and one-half the distance from its posterior edge to that of the temporal roof (? squamosal bone). Posterior outline of skull above, truncate, surface slightly convex transversely.

The premaxillary spines are short and wide, the nasals are also short and wide. The prefrontals and postfrontals form the superior edge of the orbit, excluding the frontals. The intercalaria (or ? pterotics) are very large; at the externoposterior angle is a very small element in contact with the supraoccipital which may be the true intercalare. The supraoccipitals have considerable transverse extent, running out externally in narrow apices. All the bones of the cranium are sculptured in honeycomb fashion, the ridges radiating on some of the bones. That is, on the posterior parts of the frontals and parietals and anterior part of the intercalare and squamosal. A groove follows the edge of the orbit, and turns inwards on the prefrontal bone, forming a rudimental lyra. External surface of mandible grooved below; superior part concealed.

Measurements.	M.
Width of skull between posterior angles	.018
Interorbital width	.008
Axial length of skull	.024
" from muzzle to between centres of orbits	.0096
Width of muzzle at nares	.0095
Length from orbit to nostril	.0035
Depth of skull posteriorly, to mandible	.010

The superior part of the posterior region of the inner face of the dentary bone supports a patch of small obtuse teeth, which narrows forwards into the single row of the edge of the ramus. This patch is no doubt homologous with that which is so largely developed in *Pantylus*.

The surface of the cranium has been mostly weathered away in the type of *Pariotichus, P. brachyops*, and I suspect that it is really sculptured and not smooth, as I originally stated. The *P. megalops* differs from the *P. brachyops* in the larger orbit, the narrower interorbital space, and the smaller and more numerous teeth.

Pariotichus and *Pantylus* and probably *Ectocynodon* must be referred to a special family, the *Pariotichidæ*, which has teeth like the *Edaphosauridæ** but differs from it in the entire overroofing of the temporal fossæ.

CHILONYX RAPIDENS Cope, gen. nov.

Char. Gen.—Teeth with the long diameter of the crowns transverse to that of the jaws, and with the crown contracting to a single slightly incurved apex. Maxillary series of teeth short. Temporal fossæ overroofed. Superior surface of cranium divided into more or less swollen area by grooves.

The characters above enumerated indicate for this genus a position near the *Diadectidæ*. From these it differs in the form of the teeth, and the

* Proceed. Amer. Philos. Soc., 1882, p. 450.

short and narrow maxillary bone. Two ilia accompanying the cranium have the form of those of the *Clepsydropidæ*, and differ entirely from those of the *Diadectidæ*. On the other hand, the *foramen magnum* is wide, and the exoccipitals present two articular facets downwards as in the latter family. It is possible that the genus should be referred to the *Bolosauridæ*, which is in dentition intermediate between the *Clepsydropidæ* and *Diadectidæ*.

A femur, which is included in the lot of specimens, has a wide head without trochanters, convex in the plane of the distal condyles and flat in the direction at right angles to it. There is a huge trochanteric fossa extending from the head two-fifths the length to the condyles, bordered by a ridge on each side. The condyles present in the same direction as the fossa posteriorly. They are separated by a deep anterior and posterior emargination. Their anterior edges overhang the condylar articular surfaces, making acute angles with them. One of the articular surfaces is smaller, is anteroposteriorly extended, and has a convex ectad, and concave entad border. The other surface is also anteroposterior, reaching further distad, but not so far proximad as the other. Its area is greater than that of the other, and it is deeply notched by the entering surface of the bone ectad and proximad. It is then contracted into a wide isthmus, and the lateral grooves which produce this isthmus are overhung by the expansion of the anterior face. The anterior face of the femur is without ridges or processes.

The condition of the specimen is such that the composition of the skull may be readily made out. The postfrontal bones are large, and form the superior border of the orbit. At the front of the orbit they reach the prefontal, thus excluding the frontal. The parietal bones are wider than the frontals, and are bounded laterally by the postfrontals and the squamosals and by an element between the squamosal and exoccipital, which occupies the position of the *intercalare* of the *Stegocephali*. Below this bone, on the inner side of the suspensorium, is the probable proötic. The squamosal, or an element which I cannot distinguish from that bone, extends to the condyle of the quadrate, concealing that bone from view from externally. The quadrate is short, and thins out rapidly upwards, being closely united with the squamosal. Its condyle is set at an angle of 45° with the axes of the skull, and consists of one flat and one convex surfaces, continuous but forming a deep angle together. Exterior to the exoccipital, and interno-inferior to the intercalare, is a small distinct element, apparently in the position of an opisthotic or external occipital.

The excavation for the auditory apparatus appears to be in the exoccipital. It is almost entirely filled by what I suppose to be a large stapes. This bone is in shape like a compressed flask, with the head directed inwards and forwards, and its inferior edge produced into a prominent keel, which is produced into a point below, and free from the neck of the flask. The head is truncate, and is separated from the internal cranial wall by a narrow interspace. Its external extremity is not absolutely perfect in the specimen, but does not appear to have extended in an ossified condition be-

yond the exoccipital bone. In a specimen of *Empedias molaris** there is a meatus auditorius, in which the stapes was not found on cleaning out. This element is coösified with the surrounding bones laterally and posteriorly. Consequently when broken open, the vestibule is represented by two deep grooves, directed inwards and anteriorly.

The single species of this genus is one of the largest saurians yet obtained from the Permian of North America.

Char. specif. The superior surface of the skull is everywhere flat, as is the external face of the maxillary. The surface of the latter is marked by moderately coarse fossæ and grooves, separated by more or less fine irregular but generally longitudinal ridges. The minute sculpture of the superior cranial surface, is finer and more punctate in character. The areæ of this surface, already mentioned, are arranged as follows: There is a series over the orbits, which are separated from each other by straight grooves, and which grow larger and more swollen posteriorly. Between these supraorbital rows, the areæ of the top of the skull are separated by longitudinal grooves, except immediately between the widths of the orbits, where there are some narrow transverse areæ. On the supraoccipital region there is a median subtriangular area, and three narrow longitudinal ones on each side of it. External to these, and on the posterior part of the squamosal region, the areæ are larger and more swollen. A cluster of three of these lies between the exoccipital bone, and the smooth descending surface of the posterior edge of the squamosal. Of these the one bounding the exoccipital bone, is a robust cone, forming a short horn, like that occupying a similar place in the horned toad, *Phrynosoma douglassi*. Between the temporal areæ, and in front of the supraoccipital areæ, on each side of the middle line, there are three longitudinal areæ, which are successively narrower externally, the exterior being very narrow. On the frontal region anterior to the transverse areæ, are two wide longitudinal areæ. Each nasal bone has a small median area, from which radiate grooves, of which some of the posterior are close together.

The occiput is excavated into a large fossa on each side of a large triangular supraoccipital region. The fossæ are bounded externally by a strong exoccipital crest and at the anteroinferior corner by the "opisthotic." This bone projects posteriorly and downwards, in the form of a robust hook. The foramen magnum is not excavated so abruptly above the exoccipital facets as in *Empedias molaris*.

Measurements of Skull and Femur.	M.
Interorbital width	.108
Length from supraoccipital crest to frontonasal suture	.135
Width between apices of tuberosities of the intercalaria	.113
Length from apex of tuberosities to inferior extremity of quadrate	.129

* Figured in the Proceed. Amer. Philos. Soc. xix. p. 56.

Measurements of Skull and Femur.		M.
Diameters of quadrate condyle	anteroposterior	.020
	transverse	.039
Length of maxillary on alveolar edge		.087
Diameters base of a posterior tooth	anteroposterior	.007
	transverse	.010
" of base of another posterior tooth	anteroposterior	.005
	transverse	.010
Length of femur		.236
Proximal diameters of femur	anteroposterior	.047
	transverse	.085
Width of shaft		.052
" distally (greatest)		.115

EMPEDIAS FISSUS, sp. nov.

The species of *Empedias* form a series which diverges from *Diadectes* in a successive widening of the crowns of the teeth and diminution in their number. Thus the *D. phaseolinus* is nearest to *Diadectes; D. molaris* succeeds it, and in *E. fissus* we have the molariform character most strongly developed. In the *E. latibuccatus*, on the other hand, the diminution of the transverse extent of many of the teeth and the areolar sculpture of the superior surface of the cranium points in the direction of the genus *Chilonyx*. The species of *Empedias* may be easily distinguished as follows:

I. Surface of skull divided by grooves into areæ.

Superior teeth, 16 on each side, a number on each end of the maxillary bone of little transverse extent.....*E. latibuccatus.*

II. Surface of skull uniformly rugose.

Superior teeth narrower, 16 on each side, the last one small, sphenoid flat, pterygoids narrow.....*E. phaseolinus.*

Superior teeth wider, 14 on each side, the last one smaller, sphenoid keeled medially, pterygoids wide.....*E. molaris.*

Superior teeth wider, 14 on each side, the last the largest, sphenoid not keeled.....*E. fissus.*

Of the *E. latibuccatus* I have two specimens with teeth, one including a large part of the cranium and lower jaw. Of the *E. phaseolinus* I have five specimens with teeth, one of which embraces a nearly complete skull and a large part of the skeleton. Of the *E. molaris* I have also five individuals, of which three are crania. The *E. fissus* is represented by two individuals. One of these is one side of the entire upper jaw; the other is a broken skull with the four series of molar teeth. Of other parts of the skeleton, not identified as to species, I have a large number.

The *Empedias fissus* is nearest the *E. molaris*, and has the same number of teeth. It differs, however, in various essential points. The last maxillary tooth, which is much reduced in size in the *E. molaris*, is here as large as any of the others. The portion of the crown within the medium cusp is fissured medially in the direction of its length; that is, transversely

to the axis of the jaws. This fissure is not so distinct in the mandibular teeth. The median cusp has a straight edge at right angles to the long axis of the crown. The specimen where the entire dental series of one side is preserved, shows that the latter has a sigmoid flexure, the middle of the maxillary bone being incurved, and the anterior part convex outwards. There are five or six conic teeth between the incisors and the molars.

The inferior surface of the sphenoid bone is medially flat in transverse section, and concave anteroposteriorly, in this resembling *E. phaseolinus* rather than *E. molaris*. The upper jaw specimen shows that the muzzle projects beyond the incisor teeth, which is not the case in *E. phaseolinus*, which has the incisors very prominent. The supraorbital border is regularly convex, and not depressed and notched as in *E. phaseolinus* and *E. latibuccatus*. The superior surface of the skull is marked with innumerable small impressed pits, and assumes a spongy appearance above the orbits.

Measurements.

	No. 1.	M.
Length of last six superior molars		.055
Diameters of antepenult molar	anteroposterior	.010
	transverse	.020
Diameters of crown of incisor	vertical	.013
	transverse (at base)	.007
	anteroposterior	.011
	No. 2.	
Length of dental series in a straight line		.093
Width of palate at anterior expanse		.062
" " contraction		.068
" " between widest molars		.036

Discovered by Mr. W. F. Cummins.

EMPEDIAS PHASEOLINUS Cope, Proceeds. American Philosoph. Society, May, 1880 (*Diadectes*).

The fine specimen of this species above mentioned, which was obtained by Mr. Cummins, includes some parts of the skeleton not or rarely found hitherto. The pelvis shows that the corresponding part described by me, Proceedings of the American Philosophical Society, 1882, p. 448, belongs to another species of this group, The clavicles are preserved, and enable me to identify the corresponding part of another species in which the structure is more distinctly visible. This shows an episternum wedged in between the adjacent extremities of the clavicles, which are here very robust. But a small part of it appears in the inferior surface, but superiorly it forms a plate which covers the symphysis of the clavicles, but does not extend posterior to them. The suture of the episternum with the clavicles below is a coarse interdigitation. Posterior to it is the symphysis of the clavicles.

The skull of this specimen is the first that I have seen in this group which possesses a basioccipital bone and condyle. This proves that in the five other crania of allied species, it has fallen out, which indicates its very

weak attachment to the sphenoid. The lateral superior articular facets of the exoccipital bone are characteristic of the family, and of the genus *Chilonyx*. This skull also shows that the premaxillary bones may be distinct, and that they extend but a short distance on the superior face of the muzzle.

In this species the interorbital region is wide and concave, and the parietal regions are swollen and convex. The supraorbital border is nearly straight, and has an open notch medially.

The hyposphen varies in size in different parts of the vertebral column, and is generally very large. The neural spines have bilobate extremities.

Printed April 17, 1883.

(7)

Paleontological Bulletin, No. 37.

ON A

New Basin of White River Age

IN DAKOTA.

Read before the American Philosophical Society, Sept. 21st, 1883.

ON THE

DISTRIBUTION OF THE LOUP FORK FORMATION

IN NEW MEXICO.

A SECOND ADDITION

To the Knowledge of the Fauna of the Puerco Epoch.

ON THE

Trituberculate Type of Molar Tooth in the Mammalia.

Read before the American Philosophical Society Dec. 7th, 1883.

By PROF. E. D. COPE.

FOR SALE BY A. E. FOOTE, 1223 Belmont Ave.,
PHILADELPHIA.

PALEONTOLOGICAL BULLETIN, No. 37.

From Prof. E. D. Cope, a letter to the Secretary, dated Sully Springs, Dakota, Sept. 7, 1883, was read, as follows:

On a New Basin of White River Age in Dakota.

"I have the pleasure to announce to you that I have within the past week discovered the locality of a new lake of the White River epoch, at a point in this Territory nearly 200 miles north-west of the nearest boundary of the deposit of this age hitherto known. The beds, which are unmistakably of the White River formation, consist of greenish sandstone, and sand-beds, of a combined thickness of about 100 feet. These rest on white calcareous clay, rocks and marls, of a total thickness of 100 feet. These probably also belong to the White River epoch, but contain no fossils. Below this deposit is a third bed of drab clay, which swells and cracks on exposure to weather, which rests on a thick bed of white and gray sand, more or less mixed with gravel. This bed, with the overlying clay, probably belongs to the Laramie period, as the beds lower in the series certainly do.

"The deposit as observed, does not extend over ten miles in north and south diameter. The east and west extent was not determined, but is much greater.

"The fossils, which indicate clearly the age of the formation, are the following:

PISCES.

Rhineastes, sp. nov.	2
Amiurus, sp. nov.	

LACERTILIA.

Sp. indet	1

TESTUDINATA.

Trionyx, sp.	3
Trionyx, sp.	
Stylemys, sp.	

RODENTIA.

Castor, sp.	2

CARNIVORA.

Galecynus gregarius	3
Hoplophoneus, sp	
? Hoplophoneus	

PERISSODACTYLA.

Aceratherium, sp	3
Aceratherium, sp	
Anchitherium, sp.	

ARTIODACTYLA.

Elotherium ramosum	7
Hyopotamus sp.	
Oreodon, sp	
Oreodon, sp	
Oreodon, sp	
Leptomeryx, sp.	
Hypertragulus, sp	

Total species..... 21

"Interesting features of the above catalogue are: The absence of Hyracodon and Poëbrotherium, so abundant in the beds of this age elsewhere; the presence of fishes, not hitherto detected in them; and the presence of the genius of tortoises, *Trionyx*. The latter genus has not hitherto been found in our Western lacustrine beds of later than Eocene age; while they are abundant in our modern rivers. This discovery partially bridges the interval. The same is true of the fishes mentioned, which represent the order Nematognathi."

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On the distribution of the Loup Fork formation in New Mexico. By E. D. Cope.

(*Read before the American Philosophical Society, December 7, 1883.*)

In his report on the Geology of New Mexico to the Secretary of the Interior, by Dr. F. V. Hayden, in 1869, this eminent geologist described the Santa Fé marls in their principal physical features. In 1874, in my report to Capt. George M. Wheeler, U. S. Engineers, I showed that this formation is a member of the Loup Fork division of the Miocene Tertiary, a conclusion clearly deducible from the remains of vertebrata which it contains. An illustrated report on the latter was published in the fourth volume of the report of the United States Geographical and Geological Survey, W. of the 100th meridian, Capt. G. M. Wheeler in charge(1877).

Since that time the writer has made several visits to parts of New Mexico not previously explored, and I am able to show that the Loup Fork formation has a much wider distribution in that Territory than has hitherto been supposed to be the case.

In descending the Rio Grande, beds appear on the west side of the river, which strongly resemble those of Santa Fé. They extend along the eastern base of the Magdalena mountains, and as far south as Socorro, in considerable extent and thickness. South of Socorro they appear, but less extensively. The eastern part of the plain which lies between the Rio Grande and the Mimbres mountains is composed of beds of this age where cut by the grade of the Atchison, Topeka and Santa Fé railroad, west of Hatch station. West of the Mimbres mountains the valley of the river of the same name is filled with débris of the bed of eruptive outflow which once covered the country, as far as traversed by the railroad from Deming to Silver City. Its age I could not ascertain.

A great display of the Loup Fork formation is seen in the drainage basins of the heads of the Gila river. In traveling westward from Silver City, its beds first appear in the valley of Mangus creek, which enters the Gila from the east. Crossing the Gila, the mail route to the west passes through the valley of Duck Creek, which flows eastwards into that river. Though bounded by eruptive hills and mountains and their outflows, the valley was once filled with Loup Fork beds, which have been extensively eroded, the principal exposures being on the north side of the valley, forming the foot hills of the Mogollon range. On the divide between the waters of the Gila and San Francisco rivers the formation rises in bluffs of 300 feet elevation. The descent into the valley of the San Francisco brings to light a still greater depth of this deposit. The valley which extends from the canyon which encloses the river south from the mouth of Dry creek to the Tularosa mountains on thenorth, and between the Mogollons on the east and the San Francisco range on the west, was once filled with the deposit of a Loup Fork lake. This mass has been reduced by the erosive action of the San Francisco and its drainage, to a greater or less

extent, as it has been protected by basaltic outflows or not. When so protected, the river flows through comparatively narrow canyons. Where the outflow is wanting, the valley of the river is wider, and the Loup Fork formation remains as wide grassy mesas which extend to the feet of the mountain ranges.

The age of these beds would have remained problematical but for the fortunate discovery by Mr. Robert Seip, of the skull of a species of Rhinoceros of the typical Loup Fork genus, Aphelops. It is apparently the *A. fossiger* Cope, a species abundant in the Loup Fork beds of Kansas and Nebraska. It was found near the mouth of Dry creek in a conglomerate bed of the formation.

In the valley of the San Francisco the Loup Fork beds reach a thickness of 500 feet, and consist of sand, clayey sand, soft sandstone, and conglomerates of larger and smaller pebbles of eruptive material, having a near resemblance to those of the region of Santa Fé.

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*Second Addition to the Knowledge of the Puerco Epoch. By E. D. Cope.**

(*Read before the American Philosophical Society, December 7, 1883.*)

Recent collections from the formation above-named, include many finer specimens than have been previously obtained. Skulls of several species in calcareous concretions were received, so that their characters can be developed more fully than heretofore. I mention especially *Deltatherium fundaminis; Periptychus rhabdodon* and *P. coarctatus; Haploconus lineatus; H. entoconus; Anisonchus sectorius; Protogonia plicifera; Mioclænus turgidus, M. ferox, M. subtrigonus* and *M. cuspidatus*, sp. nov. Some species hitherto rarely seen, prove to be abundant, as *Hemithlæus kowalevskianus, Protogonia plicifera, Mioclaenus minimus* and *M. subtrigonus*. With the additional species now described, the number of Mammalia from the deposit of the Puerco epoch amounts to seventy-four species.

Didymictis primus, sp. nov.

That the genus Didymictis existed during the Puerco epoch, has been already demonstrated by the discovery of the *D. haydenianus* Cope. This species is of aberrant form however, so that it remained to prove that the typical form had appeared so early in Tertiary time. This is now shown to have been the case by the discovery of the present animal, which is allied to the *D. leptomylus* of the Wind river and Wasatch epochs.

The *Didymictis primus* is known from two maxillary bones with teeth,

*The "First addition" appeared in the Proceedings of the American Philosophical Society for 1883, beginning at page 545. Since that date I have described in the Proceedings of the Philadelphia Academy, 1883, p. 168, the following species: *Periptychus coarctatus, Pantolambda cavirictus, Zetodon gracilis* (g. n.) and *Conoryctes ditrigonus*.

and a part of a mandibular bone with the last two molars in place, all belonging to different individuals. The inferior sectorial tooth is much like that of the *D. leptomylus*, but the tubercular is only two-thirds as long, and is not only absolutely, but relatively narrower posteriorly. It has the usual three cusps in a reduced condition. In the first superior true molar the external cusps are conical, and there is a small cusp between the anterior one and the produced anterior angle of the crown. There is an anterior intermediate tubercle, but no posterior one. The cingulum does not extend all round the inferior base of the crown, as it does in *D. protenus*. The sectorial has a distinct anterior basal conic lobe. The internal lobe is in transverse line with the last named, and is conical and not large.

Measurements.		M.
Diameter inferior sectorial	anteroposterior	.0138
	transverse	.0055
Diameter inferior tubercular	anteroposterior	.0050
	transverse	.0033
Depth of ramus at M. i		.0098
Diameter superior sectorial (No. 1)	anteroposterior	.0110
	transverse	.0060
Diameters superior sectorial (No. 2)	anteroposterior	0050
	transverse	.0090

The fourth specimen is especially important as presenting almost the entire dentition including canines and incisors, and the anterior part of the skull from the line of the coronoid process of the mandible. The specimen shows that the species differs from the species of the Wasatch period with oval inferior tubercular, in the absence of the posterior cutting lobe of the third, and probably fourth inferior premolar. The corresponding superior premolars are also simple. The first premolars in both jaws are one-rooted. The canines are long and acute, and are directed vertically. Both have flat facets on their external (the only visible) faces: on the superior canine I count four lateral, and one nearly anterior. On the inferior I see three lateral and one nearly anterior. There are three small superior incisors, of which the first is the largest, and has a subconical crown. The infraorbital foramen is large, and is above the anterior border of the superior sectorial.

Measurements.	M.
Length of superior dental series to front of canine	.041
" " crown of superior canine	011
" " superior true molars	.0105
Depth of ramus at inferior sectorial	.0090

In its simple premolars this species agrees with the *D. haydenianus*, and is more primitive than the Wasatch species.

TRIISODON RUSTICUS, sp. nov.

Founded on a portion of the mandible which supports the first two true molars and part of the last premolar. The species is of the type of *T.*

levisanus, but is much larger. I give here a synopsis of the species of the genus, so that its affinities may be better understood. In general, the genus *Triïsodon* is characterized by the rudimental character in the inferior molars of the anterior cusp. It is thus like *Ictops*, but differs in having the fourth premolar different from the true molars and like the premolars. From *Mioclænus* it differs in having the anterior and posterior cusps of the inferior molars unequal; the anterior forming together an elevated crest with two apices, while the posterior are low, and on the borders of a heel.

I. Cusps of inferior molars compressed.

Anterior cusp very low..... *T. quivirensis.*

II. Cusps of inferior molars not compressed.

Anterior cusp very low; *T. rusticus; T. levisanus*, and *T. assurgens.*

Anterior cusp as high as other anterior cusps to which it is closely united. *T. conidens* and *T. heilprinianus.*

In dimensions the *T. rusticus* is about equal to the *T. quivirensis*, thus exceeding the other species excepting the *T. conidens*. The interior anterior cusp is nearly as elevated as the exterior, and is united with it nearly to the apex; the anterior cusp is a tubercle which projects forwards from its anterior base. The heel of the tooth is wide, and is rounded posteriorly, and supports three tubercles, an external, a posterior and an internal, all in contact with each other. On the second true molar the internal anterior tubercle presents a slightly projecting edge anteriorly and posteriorly, which bounds a shallow vertical groove of the mass which represents their united bodies. This is not apparent in the first. The enamel is smooth, but the animal is rather old.

Measurements.			M.
Diameters of m. i	anteroposterior		.0123
	transverse		.0068
	vertical	in front	.0068
		at heel	.0038
Diameters of m. ii	anteroposterior		.0137
	transverse		.007
	vertical	anteriorly	.007
		at heel	.0062

D. Baldwin, discoverer.

Triïsodon assurgens, sp. nov.

This is the least species of the genus, and resembles in its inferior dentition the species of *Diacodon*. It is very much larger than the *D. alticuspis*, the larger species of that genus, which is found in the Wasatch formation.

The *T. assurgens* is known from a mandibular ramus which supports the last four molars, the last premolar having lost its principal cusp. The peculiarity of the true molars is seen in their generally more produced character; the anterior cusps are higher and the heels are longer. The anterior cusp is very small and basal; the principal anterior cusps are united

to near their free summits. There are the usual low marginal tubercles on the heels. That of the fourth premolar is a short simple edge.

Measurements.	M.
Length of four molars on basis	.028
" " three true molars	.0212
" "second true molar	.008
Elevation of cusps of molars	.0045
Length of last true molar	.0067
Width of last true molar	.0030
Elevation of last true molar in front	.0035

Found by D. Baldwin.

MIOCLÆNUS CUSPIDATUS, sp. nov.

The species of this genus known to me are, with the present one, nine in number. They range in size from that of a rat (*M. minimus*) to that of a wolf (*M. ferox*). The general osteological characters of the last named species are best known, and are described in the Proceedings of the American Philosophical Society, 1883, p. 547. In two of the species the superior dental series only is more or less known, and one species rests on mandibular dentition only. In the remaining seven species the dentition of both jaws is more or less known. The species may be arranged in groups as follows:

I. The posterior heel of the second inferior molar bordered by a curved edge or crest.

a. Posterior cingulum of superior true molars obsolete; *M. minimus*.

aa. Posterior superior cingulum weak; *M. turgidus*.

aaa. Posterior superior cingulum large, angulate; *M. corrugatus*; *M. ferox*.

II. The posterior heel of the second inferior molar supporting a cusp.

a. Posterior inner cusp of superior molars small, present on m. ii only; *M. cuspidatus*.

aa. Posterior inner cusp large, present on m. i and m. ii; premolars small, *M. subtrigonus*; premolars large, *M. opisthacus* (*Hemithlæus mihi olim*).

III. Second lower molar unknown. *M. protogonioides*, and *M. mandibularis*.

The supposed *M. baldwini*, resembles closely the species of *Hemithlæus*.

It is probable that two genera are here included under the head of *Mioclænus*. If the character is permanent, these will be distinguished as follows:

Third superior premolar with internal tubercle.....*Mioclænus*.
Third superior premolar without internal tubercle.....*Oxyclænus*.

The species of *Mioclænus* are *M. turgidus* (type); and very probably *M. opisthacus*, *minimus* and *M. subtrigonus*; but the diagnostic tooth has not been seen in them as yet. The species of *Oxyclænus* are: *O. cuspidatus*

and *O. corrugatus ;* and very probably, *O. ferox.* The position of the *M. protogonioides, M. baldwini* and *M. mandibularis* is uncertain, though the last two are probably *Oxyclæni.*

The *Mioclænus cuspidatus* is distinguished among its congeners, by the transverse character of its superior molar teeth, that is, by the relatively smaller anteroposterior diameter as compared with the transverse ; and by the prominence and acuteness of their principal cusps. They thus stand at the opposite extreme of the genus from the *M. turgidus,* where the teeth are characterized by the robustness and obtuseness of the cusps, although in the triangular basis of the second superior molar they agree. The external cusps are compressed cones, and in contact at the base ; the intermediate tubercles are small and distinct. The internal cusp is large and prominent. The base of the fourth premolar is T-shaped, and is as long as wide. Its internal and external cusps are well developed. The cingulum of the true molars is complete all round on the last one, and on the two others except at the internal base, where it is interrupted. The second molar only displays a posterior inner tubercle of the cingulum, which is small, and does not give a truncate interior outline of the crown, characteristic of *M. opisthacus, M. ferox,* etc. On the ms. i and ii, the cingulum is expanded at the external angles of the crown, most so anteriorly. The anterior expansion rises in a low cusp in the P-m. iv. The enamel is smooth.

This species need only be compared with *M. opisthacus* and *M. subtrigonus,* which are of about the same size. Passing by the differences already mentioned in the table, the fourth premolar has a different form from that of the *M opisthacus.* In the latter it is narrower and more transverse, and with larger conical cusps, much as in *M. turgidus ;* in the present species it has the trilobate outline seen in *M. subtrigonus.* As to the latter species, the teeth are wide, and the cusps smaller and separated at at the base, and the cingulum is crenate and lobate, in a manner quite different from the smoothness and compactness of structure seen in the *M. cuspidatus.*

Measurements.	M.
Length of base of last four superior molars	.026
" " " three true molars	.019
Diameters of P-m. iv { anteroposterior	.006
Diameters of P-m. iv { transverse	.004
Diameters of m. i. { anteroposterior	.006
Diameters of m. i. { transverse	.006
Diameters of m. ii { anteroposterior	.0064
Diameters of m. ii { transverse	.008
Diameters of m. iii { anteroposterior	.0045
Diameters of m. iii { transverse	.006

D. Baldwin, discoverer.

CHRIACUS TRUNCATUS, sp. nov.

The genus *Chriacus* m. was characterized in the Proceedings of the

Academy of Philadelphia, 1883, p. 80, and two species were mentioned, *C. pelvidens* (type) and *C. angulatus*. The former of these is from the Puerco, the latter from the Wasatch formation ; the former is the larger species ; the latter quite small. I now add two species to the genus which are intermediate in dimensions between those already known.

I. Posterior cingulum of superior molars with large tubercle.

Large species ; *C. pelvidens ;* small species, *C. truncatus.*

II. Posterior cingulum with small tubercle ; small species ; *C. angulatus.*

III. Posterior cingulum without tubercle ; small species ; *C. simplex.*

In the *C. truncatus* the posterior singular (inner) tubercle reaches the largest development, but is not present on the cingulum of the last superior molar. The anterior cingulum is weak on that tooth and on the first true molar, but on the second it is thickened into a small anterior or inner tubercle. This with the posterior inner gives the crown a truncate internal outline, as is also the case in the *C. pelvidens.* The intermediate tubercles are distinct, and the external cusps are separate at the base. An external cingulum. The fourth premolar has a triangular base ; a single compressed external cusp, and a small acutely conical internal one. The internal tubercle is small and acute on the third premolar. The second premolar is small and probably one-rooted, and it is possible that there is no first premolar. The canine is directed vertically downwards, and the base of the crown is oval.

Besides the considerably smaller size, the posterior internal cusps are relatively larger than in *C. pelvidens.*

Measurements.	M.
Length of superior dental series including canine	.039
Length of true molar series	.014
Diameters P-m. iii anteroposterior	.004
Diameters P-m. iii transverse	.003
Diameters P-m. iv anteroposterior	.004
Diameters P-m. iv transverse	.005
Diameters M. ii anteroposterior	.005
Diameters M. ii transverse	.0064
Diameters m. iii anteroposterior	.0033
Diameters m. iii transverse	.005

Two individuals from New Mexico. D. Baldwin.

Chriacus simplex, sp. nov.

This species is represented by a part of the left maxillary bone, which supports the true molars except a part of the last one ; and by parts of the mandible, with the first and second true molars, and perhaps one of the premolars. The true molars are about the size of those of the *C. truncatus,* but of very different detailed structure, as already pointed out. The posterior cingulum is stronger than the anterior, but does not support a trace of a cusp, and they do not unite on the inner face of the crown. External

cingulum present. External cusps rather small, separate. Intermediate cusps present; V large and distinct. Enamel smooth.

The inferior true molars support Vs; in the second the anterior is smaller and is more elevated than the posterior. The latter is continued as a raised posterior, and partly interior border of the heel, without prominent cusp. The crown has a distinct external and a very faint internal cingulum. In the supposed first true molar, the anterior V is more prolonged anteroposteriorly as in the corresponding tooth of *Mioclænus ferox*, etc., and the fourth premolar of *Phenacodus primævus*. The anterior cusp is the lowest. The heel supports three low cusps, of which the external has a crescentic section, and the posterior is the smallest.

It is probable but not certain that the fourth premolar has an internal cusp, as the tooth, presumably this one, is injured at that point. Should the internal cusp be absent, this species cannot be referred to *Chriacus*.

Measurements.		M.
Length of superior true molars		.0135
Diameters of first true molars	anteroposterior	.005
	transverse	.006
Diameters of second true molars	anteroposterior	.0053
	transverse	.007
Diameters of third true molar	anteroposterior	.0034
	transverse	.006
Diameters of first inferior true molar	anteroposterior	.005
	transverse	.0035
Diameters of second inferior true molar	anteroposterior	.0056
	transverse	.0043

D. Baldwin, discoverer.

TRICENTES CRASSICOLLIDENS, gen. et sp. nov.

Char. gen. This genus is *Chriacus* with only three premolars in the superior, and probably inferior series. The canines are well developed, and lateral in position, leaving space for small incisors, thus differing from the genera of the *Mixodectidæ*, *Mixodectes*, *Microsyops*, and *Cynodontomys*, on the one hand, and from *Necrolemur* on the other. It has, so far as known, the dental formula of several genera of typical Lemuridæ, but differs from these in the following points. The orbit is open posteriorly; the inferior molars have the anterior triangle of three cusps; and the fourth inferior premolar has an interior cusp. I have demonstrated the last mentioned characters on the type, *T. crassicollidens* only, but suspect its presence on some or all of the other species. In their details the superior true molars are like those of Mioclænus, as distinguished from those of Pelycodus.

To this genus belongs the *Mioclænus subtrigonus*, and probably, from the small size of its fourth premolar, the *M. bucculentus*. I add to these three a fourth, *T. inæquidens*, and remark that it is yet uncertain how many premolars are present in the *Chriacus simplex*. Should the latter possess three only, it will be properly referred to Tricentes.

These species differ as follows :

I. Posterior cingulum of true molars i and ii, wide, rising into a small cusp.

Length of true molars, M. .0155.....*crassicollidens.*

II. Posterior cingulum distinct, thickened inwards.

Length of true molars (m. ii inferential) .0175, crowns narrowed, transverse.....*bucculentus.*

Length of true molars .0170 ; crowns quadrate.....*subtrigonus.**

Length of true molars .0135 ; crowns narrowed, transverse.....(*Chriacus*) *simplex.*

III. Posterior cingulum weak, disappearing inwards.

Length of true molars .0105, crowns transverse except the third, which is very small.....*inæquidens.*

Char. Specif. The *Tricentes crassicollidens* is about the size of the *Chriacus truncatus* and resembles it a good deal. The latter has, however, a more transverse form of true molars, as compared with the present species, where the form is subquadrate. In the present animal the premolars are smaller, and if the third (second present) has an internal cusp, it is much more insignificant than in the *C. truncatus.* These two species and the *Mioclænus opisthacus* resemble each other in the similar size, and in the true molars having the posterior inner cusp more distinct than in other species. They differ in the dimensions of their premolars, those of the *M. opisthacus* being the largest, and those of *C. truncatus* being intermediate in size. In the *T. crassicollidens* the anterior cingulum is also distinct. The external cusps are conic, and are well separated, and the internal V is distinct. The internal cusp of the fourth premolar is small and compressed, so as to be transverse. The base of the third premolar is triangular and much longer than wide. All the superior molars, except the first premolar, are furnished with an external cingulum, which rises into a more or less distinct apex at its anterior and posterior angles. The first premolar is a simple cone. The alveolus of the canine tooth is of large size. The last true molar is not much reduced, and the first is as large as the second. This is not the case with the *T. bucculentus,* where the first is considerably smaller than the second.

Measurements.	M.
Length of dental series to canine, exclusive	.036
" " diastema	.006
" " premolar series	.0143
" " true molar series	.0152
Diameter of P-m. iv anteroposterior	.0042
Diameter of P-m. iv transverse	.0042

*There may be two species confounded under this name. A specimen figured in Vol. III of the final (4to) Report of the Hayden Survey, Plate XXIV, f, fig. 4 has four inferior premolars, all simple.

Measurements.		M.
Diameter of M. i	anteroposterior	.0058
	transverse	.0050
Diameter of M. iii	anteroposterior	.0030
	transverse	.0048

A pair of mandibular rami, found on the same day, and at or near the same place, probably belong to the same species, if not to the same animal, they support all the teeth, but only the P-m iv and the M. i and ii have yet been disengaged from the matrix. The P-m. iv is rather large and robust, and has a short wide heel, and an anterior cusp which leaves the main cusps half way to the apex, or at the same elevation as the internal cusp. The anterior three cusps of the true molars are elevated above the heel, and the anterior is nearly median, forms no blade with external anterior, and is smaller than the anterior internal cusp. The heel is well developed, and its borders rise in two obtuse open Vs, whose apices look away from each other. The internal supports two cusps, the external, but one. No cingula; enamel smooth.

Measurements of inferior teeth.		M.
Diameters of P-m. iv	anteroposterior	.0060
	transverse	.0035
Diameters of m. ii	anteroposterior	.0050
	transverse	.0039
Length of bases of m. i and m. ii		.0110

From Upper Puerco; D. Baldwin.

TRICENTES INÆQUIDENS, sp. nov.

This species is represented by two mutilated crania, obtained on the same day and near the same locality as the preceding species. One of these, which I select as type, embraces the muzzle and palate anterior to the posterior border of the maxillary bone.

Besides its inferior size, other characters distinguish this species. The simplicity of the superior molars is seen in no other, and the very reduced size of the third superior molar is not found in any of its allies. This is correlated with an oblique reduction of the maxillary bone behind, which gives the second true molar an oblique external border instead of the longitudinal one seen in the other species. The external cusps of the molars are conic, and are not in contact at the base. The internal cusp is also conic, and is larger than the external. The internal cusp of the fourth premolar is large. It is probable that the third premolar supports an internal cusp, as the crown base is as wide as long. The premolars are spaced in this species, as in the last, but the diastema is shorter than in the *T. crassicollidens*, not exceeding the premolar interspaces. The external cingulum is quite weak. The canine alveolus is large. The incisors are wanting, but the premaxillary region is wide. The inferior dentition is unknown.

Measurements of superior teeth.	M.
Length of dental series, including canine	.0272
" from canine to m. i, exclusive	.0130
Length of true molar series	.0100
Diameter of P-m. iii { anteroposterior	.0028
transverse	.0025
Diameters of P-m. iv { anteroposterior	.0030
transverse	.0042
Diameters M. i { anteroposterior	.0038
transverse	.0048
Diameters M. ii { anteroposterior	0039
transverse	.0059
Diameters M. iii { anteroposterior	.0015
transverse	.0024

Upper Puerco ; D. Baldwin.

INDRODON MALARIS, gen. et sp. nov.

Char. gen. Family Anaptomorphidæ, suborder perhaps Lemuroidea, as indicated by the dentition only. It differs from *Anaptomorphus* in three points. First, there are three superior incisors ; second, the first (third) premolar has no internal lobe ; and third, there is a distinct posterior internal tubercle on the first and second superior molars.

The animals of the Eocene period of the family of the *Adapidæ*, may belong to the *Lemuroidea*, but the evidence which I have derived from the feet of *Pelycodus** has led me to refer them† to the Insectivorous division of the Bunotheria, to the neighborhood of the Tupæidæ and Erinaceidæ. At the same time I retained provisionally the genera with three and two superior premolars in the suborder Lemuroidea, although the foot structure of these extinct genera is yet unknown. I also indadvertently defined the Lemuroidea as having quadrituberculate superior molars, a character which I well knew to be wanting in various extinct and recent genera where they are tritubercular. Two families were proposed† for the Eocene lemuroids, which are defined as follows :

Superior premolars three ..... *Mixodectidæ.*
" " two ..... *Anaptomorphidæ.*

The genera of the first named family are defined as follows :

I. Canine teeth large and lateral, well separated.
First superior premolar without internal lobe ; superior true molars tritubercular with cingula ..... *Tricentes.*

II. Canine teeth median in position or much reduced in size.
a. Last inferior premolar without internal tubercle.
Inferior premolars all one rooted ; canine and incisor small. . *Necrolemur.*‡

* Report of U. S. G. G. Survey W. of 100th Mer. G. M. Wheeler, iv, p. 140.
† Proceedings Academy Natural Sciences, of Philadelphia, 1883, p. 78-80.
‡ Filhol Rech. Phosph. Quercy.

First premolars only one-rooted ; canine small ; incisor very large.....*Mixodectes.**

aa. Last inferior premolar with internal tubercle.

A very large ? canine ; first premolar only, one-rooted.....*Microsyops.*†

A very large ? canine ; first and second premolars both one-rooted.....*Cynodontomys.*‡

The genera of Anaptomorphidæ, which on dental characters includes *Indrodon*, differ as follows :

a. Incisors three.

First superior incisor without inner lobe ; posterior inner tubercle present on first and second tubercle.....*Indrodon.*

aa. Incisors two.

First superior incisor with inner lobe ; no posterior inner tubercle on superior molars.....*Anaptomorphus.*

The superior dental formula of *Indrodon* is I. $\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{2}{2}$; M. $\frac{3}{3}$. The canine is compressed and acute ; the third premolar is compressed conic, and has two roots. The fourth premolar has but one external cusp. The external cusps of the true molars are conic and acute, and are connected with the internal cusp by ridges which form a V. Posterior inner cusp distinct on ms. i and ii, a part of the posterior cingulum. Intermediate tubercles present, small. The superior incisors are well developed, and display no tendency towards the rodent type. A portion of lower jaw adheres to the skull, and may belong to the same animal. It supports the last two molars. These have two anterior, opposite, approximated cusps. The heel of the penultimate molar is rather large, and has a raised edge, which develops low tubercles at the angles.

Char. Specif. The first and third superior incisors are a little larger than the second. Canine preceded and followed by diastemata, each of which is 1.5 times as long as the long diameter of the base of the crown. Premolars separated from each other and from the first true molar by interspaces half as long as the diastema. Neither tooth has any basal tubercles, but the posterior has a weak external cingulum, which is stronger posteriorly. The internal cusp of the same tooth is anterior, is acute and elevated. The superior true molars have a strong external cingulum, which rises into a small tubercle opposite the space between the external principal cusps. Of the latter, the anterior is a little more conic than the posterior, and both are well within the external border. On the last molar, the posterior external cusp is continuous with the external intermediate tubercle, and forms a cutting edge within the posterior margin of the crown. The posterior inner tubercle is rather large, and projects further inwards than the apex of the anterior V on the second true molar, but not so far as in the species of *Anisonchus* and *Haploconus*.

*Proceedings American Philosophical Society, 1883, p. 559.

†Leidy Report U. S. Geol. Survey, Terrs. I.

‡Cope, Pal. Bull., No. 34.

The surface of the cranium is too much obscured by cracks and films of matrix to permit a view of the sutures and foramina. The face is wide, as the posterior part of the maxillary and the malar bone are expanded outwards. I have not yet been able to ascertain the condition of the orbit posteriorly. The mandibular ramus is rather slender.

Measurements.	M.
Length of dental series from posterior base of i iii.	.0248
" " bases of superior incisors.	.0060
" from i iii to P-m. iii, exclusive.	.0074
" of premolars on maxillary bone.	.0060
" " base of P-m. iii	.0020
" " P-m. iv	.0028
Width " "	.0038
Diameters m. i { anteroposterior	.0030
Diameters m. i { transverse	.0032
Diameters m. ii { anteroposterior	.0033
Diameters m. ii { transverse	.0040
Diameters m. iii { anteroposterior	.0030
Diameters m. iii { transverse	.0040
Diameters inferior m. ii { anteroposterior	.0032
Diameters inferior m. ii { transverse	.0030
Depth of ramus mandibuli at m. ii.	.0070

The skull is about the size of that of the *Bassaris astuta*. D. Baldwin, discoverer.

The discovery of this type in the Puerco formation is a fact of interest. In the shortening of its dental series it is the most specialized genus of the epoch, while the forms of its true molars are like those of the simpler Creodonta, and more specialized than those of *Anaptomorphus*, and the lemurs generally. In the simplicity of its premolars, however, it maintains the general character of the Puerco fauna, and is more primitive than the forms just named. Its nearest ally of the Puerco yet known is *Chriacus*.

ANISONCHUS AGAPETILLUS, sp. nov.

This species is founded on parts of six mandibular rami, none of which has more than four continuous molars in position, including the last. It is not entirely certain that these belong to a species of *Anisonchus*, because the superior molar teeth by which that genus is distinguished from *Haploconus* and *Hemithlæus*, are wanting. The inferior molars have the anterior inner cusp moderately well developed, as in *Anisonchus gillianus*.

The crowns of the true molars consist of two Vs; of which the posterior base of the posterior one, is rendered irregular by the presence of a small posterior median tubercle. Of the anterior pair of cusps, the external is a little the more elevated, and the internal is more elevated than any of the posterior ones. The internal posterior as well as the external posterior

cusp has a V-shaped section, because its anterior border is continued as an oblique ridge to the base of the anterior internal cusp. Internal cingula none; a slight one on the external base of the large anterior external cusp. The heel of the third true molar is well developed, and rises into an acute cusp. That of the fourth premolar is short and flat. The anterior cusp of the same is basal and rudimental. This tooth is not enlarged as is usually the case in the *Periptychidæ*, and it first here differs from these animals, and agrees with the unguiculate types in that its lateral faces are unequally convex.

Measurements.	M.
Length of last four molars on base	.014
" " fourth premolar	.0035
Elevation of " "	.0038
Length of second true molar	.0031
Width " " " (greatest)	.003
Length of third " " "	.004
Width " " " "	.0028
Depth of ramus at second true molar	.007

ANISONCHUS COPHATER, sp. nov.

A mandibular ramus supporting three molars, two of them true, is all that I have seen of this species. Its proportions are the same as those of the *A. agapetillus*, that is, much smaller than the *A. gillianus*, and the single premolar is much more like that of other species of the genus. The true molars differ from those of the *A. agapetillus* in two strong characters. First, the internal posterior cusp is inside the rim of the heel of the crown, that is, outside the bordering edge, and is therefore very distinct from the posterior median cusp. It is a sharp cone; secondly, there is a cingulum extending from this cusp round the internal base of the internal anterior cusp. There is also one at the base of the external anterior cusp, which continues to the heel only on the last inferior molar. The posterior heel is relatively wider, and the anterior V relatively more contracted, than in the *A. agapetillus*. The anterior tubercle is moderately developed at the anterior base of the anterior V. The third or fourth premolar is equilateral, and larger than the true molars. It has a short apiculate heel, and a rudimental anterior basal tubercle.

Measurements.			M.
Diameters of m. ii	horizontal	anteroposterior	.0032
		transverse	.0030
	vertical	anterior	.0025
		posterior	.0013
Diameters of P-m. iii or iv	anteroposterior		,0043
	vertical (restored apex)		.0040
	transverse		.0023

D. Baldwin, discoverer.

CHIROX PLICATUS, gen. et sp. nov.

Char. gen. These are known from three superior molars; viz: the last

premolar, and the second and third true molars. The fourth premolar has two external, and one internal cusps, and the true molars have four cusps each. The cusps are of peculiar form. The second true molar resembles a convex body which has been divided by two cuts at right angles to each other, from which the quarters thus produced has spread away from each other subequally. The external faces of the cusps are convex. The apices are acute. The last superior molar is larger anteroposteriorly than transversely. The fourth premolar (supposed) is two-rooted.

These molar teeth remind one of the inferior molars of *Ptilodus*, through they differ much from them. The genus is probably nearer to *Catopsalis*, and belongs to the Marsupial order. The presence of only two series of cusps in the superior molars, distinguishes it from these genera, which have presumably three series of such cusps. Lemoine has shown this to be the case in *Neoplagiaulax*.

Char. specif. The external cusps of the fourth premolar are flattened on the external side, and lean a little inwards. The internal cusp (probably homologically the anterior) is opposite the anterior external, and has a convex internal face. Its apex is acute and compressed; the apices of the external cusps are trihedral and acute.

The cusps of the second true molars are more widely separated transversely than anteroposteriorly; that is, the longitudinal fissure is wider than the transverse. The apices are all acute, the internal trihedral, the external more compressed.

The transverse diameter of the last true molar is smaller than that of the second true molar, while the longitudinal is nearly the same. The crown projects convexly posterior to the posterior pair, and there is a small tubercle at the anterior base of the external anterior cusp.

None of the teeth preserved display cingula. The bases of the crown are smooth, but the cusps are sharply and finely parallel-grooved on their external faces.

Measurements.		M.
Diameters of P-m. iv	anteroposterior	.0030
	transverse	.0038
Diameters of m. ii	anteroposterior	.0033
	transverse	.0035
Diameters of m. iii	anteroposterior	.0035
	transverse	.0030

D. Baldwin, discoverer.

CATOPSALIS FISSIDENS, sp. nov.

This Marsupial is represented by a portion of the lower jaw which supports the molar teeth. The first, which is probably the fourth premolar, is represented only by its single root, which fills a round alveolus near the anterior base of the first true molar.

In size this species is intermediate between the small *C. foliatus* and the large *C. pollux*. The first molar is the longer and narrower, and the

second the shorter and wider, as in the known species. The first molar differs from that of both the latter, in having the tubercles of one side separated nearly to the base. These tubercles are conic, and not flattened as in *C. foliatus* and *C. pollux*, and the two rows are separated by a distinct valley, as in the first named. There are five tubercles on one side, and four on the other side of the crown, and in addition, two small cusps at the anterior extremity of each row, and another at the posterior extremity of one of the rows. These additional cusplets are not present in the other species.

The last molar is relatively wider than in the other species. Its crown is a good deal worn, but there are probably more than two rows of tubercles, as there are some appendicular rows on one side of the crown at least.

Measurements.		M.
Diameters M. i	anteroposterior	.0135
	transverse	.0050
Diameters M. ii	anteroposterior	.0090
	transverse	.0075

The Upper Puerco ; D. Baldwin.

General remarks on the characters of the Mammalia of the Puerco Epoch.

I have already called attention to the fact that the Mammalia of the Puerco epoch possess, with but few exceptions, superior molar teeth whose crowns include only three of the component tubercles of the normal mammalian molar, in a condition of full development.* In the number of species of supposed placentals now known, sixty-seven, the proportion of species (1), with quadrituberculate superior molars is even smaller, being only four to sixty-three. The premolars display equally primitive characters, and to these I wish now to draw attention.

2. The presence of two internal tubercles of the fourth superior premolar is unknown as yet in the fauna.

3. The presence of two external cusps of the same tooth is known or inferred in only five species in the sixty-seven, and in two of the five it is of reduced size.

4. The presence of one internal cusp of the fourth superior premolar is demonstrated or inferred in all of the placental species.

5. The presence of the internal cusp of the third superior premolar is, on the other hand, only demonstrated in twenty-two species. In seventeen it is wanting.

Referring to the inferior premolars :

6. No species presents an internal cusp of the third premolar.

7. An internal cusp of the fourth premolar is present in only fourteen species. In twenty-nine species it is certainly wanting.

* Proceedings of the American Philosophical Society, 1883, 562. American Naturalist, 1883, 407.

8. In no species of this formation is the fourth inferior premolar like a molar tooth.

It is thus evident that the dentition of the mammalia of the Puerco fauna presents a much greater degree of simplicity than does that of the species of any of the later Eocene or other age. This result coincides with the results I have already obtained from a study of the structure of the feet, etc.* These may be summarized again as follows:

1. The species in which the number of toes is known, have them 5–5.

2. Those in which the feet are known are plantigrade.

3. No species is known to have interlocking carpal and tarsal bones, excepting the two species of *Pantolambda* (carpus unknown).

4. No species is known to have well grooved astragalus (its presence is inferred in two species of *Dissacus*).

5. No species is known to have a faceted radius or ulno-radius, adapted to the separate carpal bones of the proximal row.

6. In no species is the tongue in the metapodio-phalangeal joints developed on the front of the metapodial bones.

7. The zygopophyses where known are all flat, except in some species (probably all) of *Oxyclænus*, where they are simply convex-concave, and not doubly so.

On the Trituberculate Type of Molar Tooth in the Mammalia. By E. D. Cope.

(*Read before the American Philosophical Society, Dec. 7, 1883.*)

It is now apparent that the type of superior molar tooth which predominated during the Puerco epoch was triangular or tritubercular; that is, with two external and one internal tubercles.† Thus, of sixty-seven species of placental mammalia of which the superior molars are known, all but four have three tubercles of the crown, and of the remaining sixty-five, all are triangular, excepting those of three species of Periptychus, and three of Conoryctes, which have a small supplementary lobe on each side of the median principal inner tubercle.

This fact is important as indicating the mode of development of the various types of superior molar teeth, on which we have not heretofore had clear light. In the first place, this type of molar exists to-day only in the insectivorous and carnivorous Marsupialia; in the Creodonta, and the tubercular molars of such Carnivora as possess them (excepting the plantigrades.) In the Ungulates its persistence is to be found in the molars of the Coryphodontidæ of the Wasatch, and Dinocerata of the Bridger Eocenes. In later epochs it is occasionally seen only in the last superior molar.

It is also evident that the quadritubercular molar is derived from the tritubercular by the addition of a lobe of the inner part of a cingulum of the

* American Naturalist, 1883, p. 1056; Science, 1883, p. 275.

† See *American Naturalist*, April, 1883, p. 407.

posterior base of the crown. Transitional states are seen in some of the Periptychidæ (*Anisonchus*), and in the sectorials of the Procyonidæ.

The tritubercular or triangular superior molar is associated with a corresponding form of the anterior part of the inferior molar, This kind of inferior molar* I have called the tubercular sectorial, and is very variable as to the degree of development of the sectorial cutting edge. The anterior triangle is formed by the connection by angle or crest, of the median and anterior internal crests with the anterior external. Its primitive form is seen in Didelphys, Pelycodus, Pantolambda and the Amblypoda generally ; in Centetes and Talpa ; and in its sectorial form, in Stypolophus and Oxyæna, etc.

The mechanical action of such teeth is as follows : Of course, it results from the form of the superior molars that the spaces between them are wedge-shaped, the apex external, the base opening to the palate. The base of the triangular section of the anterior part of the inferior molar is interior, and the apex exterior, and when the jaws are closed, this triangular prism exactly fits the space between the superior molars. The lower heel of the inferior molar receives the impact of the crown of the superior molar. Thus the oblique edges of the inferior triangle shear on the edges of two adjacent superior molars. The anterior parts of the inferior molars, and the superior molars, form an alternate dental series as distinguished from the prevalent opposed dentition of most mammalia. In so far it resembles the reptilian dentition.

This primitive dentition has been modified in two directions ; viz. to form the grinding and the sectorial dentitions. As already remarked, the superior molars gradually acquire a posterior internal lobe, which produces the quadrituberculate type. This lobe, by opposing the anterior internal lobe of the next posterior inferior molar, precludes the entrance of the anterior triangle of the latter between the two superior molars. Hence we find in the types which possess quadritubercular superior molars, that the anterior triangle of the inferior molar is not elevated, if present, as for instance in Rhinocerus. It is, however, more frequently atrophied, and disappears, forming the inferior quadritubercular molar so well known.

On the other hand, as I have pointed out,† the anterior internal cusp of the triangle of the inferior molar may be more developed anteroposteriorly, giving the antero-internal edge of the triangle much greater obliquity than the postero-internal. In correspondence with this modification, the superior triangular molar loses its equilateral character by the more anterior position of its internal angle, thus elongating the posterior internal side of the crown. The latter thus fits the corresponding form of the triangle of the inferior molar, forming with it the shear of the sectorial tooth.

*See Report G. M. Wheeler, D. Chief of Engineers on Explor. Surv. W. 100th Mer. Vol. IV, pt. II ; on the Creodonta.

† On the origin of the sectorial tooth of the Carnivora, *American Naturalist*, 1875.

In a former article, "On the Homologies of the Molar Teeth," etc., I traced the modifications of the superior and many of the inferior molars of the ungulate mammals to a parent quadrituberculate type. In a subsequent essay* I traced the origin of the inferior sectorial to a primitive five-tubercled, or "tubercular sectorial" type. Farther than this I did not go, and made no attempt to derive the few cases of triangular superior molars then known, nor the type of the superior sectorial. The revelations of the Puerco fauna show, that the superior molars of both ungulate and unguiculate mammalia have been derived from a tritubercular type; and that the inferior true molars of both have been derived from a "tubercular sectorial" type. Shall we look for the origin of the latter in a tritubercular tooth also, *i. e.* tubercular sectorial without heel; and will the crowns of the true molars of the primitive mammals alternate with, instead of oppose each other? This is a probable result of future discovery.

*Journal Academy Natural Sciences, Philadelphia, March, 1875.

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aleontological Bulletin, No. 38.

SYNOPSIS

OF THE

PECIES OF OREODONTIDÆ.

(Read before the American Philosophical Society, January 18, 1884.)

ON THE

STRUCTURE OF THE SKULL

IN THE

lasmobranch genus Didymodus.

(Read before the American Philosophical Society, March 7, 1884.)

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Synopsis of the Species of Oreodontidæ. By E. D. Cope.

(*Read before the American Philosophical Society, January 18, 1884.*)

The tribe Ruminantia first appears in the White River Miocene period in North American geological history. It is represented there by a number of genera, which pertain to several family types. The most aberrant of these, the *Oreodontidæ*, includes the largest number of forms, generic and specific. The *Poëbrotheriidæ* certainly embraces but few species, while a third group of genera, represented by Leptomeryx, which are intermediate between the *Tragulina* and *Pecora*, and should be perhaps regarded as aberrant *Tragulidæ*, also includes a small number of species.

The *Oreodontidæ* constitute a family related to the *Anoplotheriidæ* of the later Eocene, but representing a more specialized condition of the structure of the molar teeth, in the full development of the selenodont type, which is rudimental in the *Anoplotheriidæ*. Their feet, on the other hand, are less specialized than in the latter family. As a family, the *Oreodontidæ* display very little tendency in their limbs to the specialized condition of the *Ruminantia*, but are more like those of the suilline groups, and, among recent families, of the *Hippopotamidæ*.

OREODONTIDÆ.

Dentition; superior incisors present; molars selenodont. Cervicals with the transverse processes perforated by the vertebrarterial canal. No alisphenoid canal. Ulna and radius, and tibia and fibula distinct. Metapodial bones four on each foot, with incomplete distal trochlear keels. Lunar bone not supported by magnum. Navicular and cuboid bones distinct.

The preceding synopsis of its characters should furnish a basis for the definite location of the *Oreodontidæ* in the system. Dr. Leidy called its species Ruminating hogs, and created a family for Oreodon and the allied genera, under the name of *Oreodontidæ*. This family is adopted by Prof. Gill who includes in it the *Agriochoeridæ* of Leidy, and places it in his division *Pecora*, which is more comprehensive than the *Pecora* of Prof. Flower, being nearly identical with the *Selenodonta* of Kowalevsky. More precise expression of its affinity to the existing families is not given, excepting to place it under a division "incertæ sedis."

As a selenodont type, this family is excluded from the *Artiodactyla omnivora*, and as having its metapodial bones distinct, it cannot be placed in any recent family excepting the *Tragulidæ*. From this family it is distinguished by the distinct ulna and radius. We then turn to the extinct families *Poëbrotheriidæ* and *Anoplotheriidæ*. The former agrees with the *Tragulidæ* excepting in its Cameloid cervical vertebræ, while the latter differs from the *Oreodontidæ* in the structure of the feet. The *Anoplotheriidæ* are didactyle in front, and tridactyle behind. The posterior foot has a well-developed second digit directed

more inwards than the others, which it is supposed supported a natatory web. In the Oreodontidæ all the feet are regularly tetradactyle.* The Anoplotheriidæ differ also in the presence of an additional cusp on the inner side of the superior molars, accompanied by an imperfect development of one or both pairs of the internal crescents. In *Anoplotherium* the internal crescents of the inferior molars are incomplete, and more or less represented by tubercles. In the *Oreodontidæ* there are two pairs of fully developed crescents, and no internal tubercles. The details of the structure express various affinities. The axis is intermediate between that of the suilline and ruminant *Artiodactyla;* the other cervicals are suilline, while the remaining vertebræ are ruminant. The scapula is ruminant, not suilline; while the humerus is like nothing but *Anoplotherium.* The radiocarpal articulation is intermediate between that of hogs and ruminants. The unciform supports the lunar bone. The sacrum is ruminant, the ilium suilline. The femur and tarsus are much like those of the peccary.

The genera of this family known to me are the following:

I. Orbit incomplete; last premolars in both jaws with two external crescents or Vs.

Premolars three. ..... *Coloreodon.*
Premolars four ..... *Agriochoerus.*

II. Orbit complete; premolars four, the fourth with one external crescent.

a. No facial vacuities.

Premaxillaries distinct; otic bullæ not inflated. ..... *Oreodon.*
Premaxillaries distinct; otic bullæ inflated. ..... *Eucrotaphus.*
Premaxillaries coössified; otic bullæ inflated. ..... *Merycochoerus.*

aa. Facial vacuities present.

Premaxillaries coössified, dentigerous; vacuities prelachrymal only. ..... *Merychyus.*
Incisors six above, persistent; vacuities prelachrymal and prefrontal; nasal bones much reduced. ..... *Leptauchenia.*
Incisors very few, caducous; vacuities very large. ..... *Cyclopidius.*

III. Inferior premolars three.

True inferior canine functional; inferior incisors one on each side. *Pithecistes.*

The number of species referred to these genera in the succeeding pages is as follows:

Oreodon	3
Eucrotaphus	3
Merycochœrus	7
Merychyus	6
Leptauchenia	3
Cyclopidius	2
Pithecistes	3
Agriochoerus	6
Coloreodon	2
	35

* I have observed this in the genera Oreodon, Eucrotaphus, Merycochœrus, and Merychyus.

The present paper is chiefly devoted to the proper distinction of these species and genera or cranial characters only. Figures of all will be given in my volume which embraces this subject, in the Report of the U. S. Geological Survey of the Territories.

Coloreodon ferox Cope, one-half natural size. Original; from Report U. S. Geolog. Survey Terrs., vol. iii, F. V. Hayden in charge.

OREODON Leidy.

Proceedings Academy Philadelphia, 1857, p. 238. Ancient Fauna of Nebraska, Smithsonian Contrib. to Knowledge, 1853, p. 29. Extinct Mammalia Dakota and Nebraska, 1869, p. 72. Report U. S. Geological Survey Terrs., 1873, I, p. 201. *Merycoidodon* Leidy, Proceeds. Acad. Philada., 1848, p. 47 (nomen nudum). *Cotylops* Leidy, Loc. cit., 1851, p. 239.

Premaxillary bones distinct from each other. Otic bullæ not inflated. No lachrymal vacuity of the face ; nasal bones normal. Premolars four in both jaws.

Dental formula I. $\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$; the series uninterrupted. Crowns of the molars robust, well distinguished from the roots. Grinding surface of the true molars simply selenodont, *i. e.*, with but two pairs of crescents. Superior premolars composed of a single external compressed cusp with crescentic section, and internal cingula or crescent. The fourth premolar with a well developed internal crescent ; the first three with rudimental internal crescents in the form of basal cingula. Superior canines distinct. Inferior premolars of two kinds ; the first canine-like in form and function ; the others consisting of a single external cutting edge rep-

resenting two crescents, of which the anterior has its posterior horn developed as an obliquely transverse crest directed inwards. Last true molar with a heel composed of two columns.

In the superior temporary dentition the last premolar has the form of the first permanent true molar. The third premolar has five lobes, *i. e.*, four crescents and an anterior odd one. The other temporary premolar resembles that of the permanent series. The last inferior temporary premolar has the three pairs of lobes usual in the *Artiodactyla*, and the two which precede it resemble the corresponding permanent teeth. Says Leidy :* "The permanent true molars successively protrude and occupy their functional position before any of the deciduous molars are shed. The displacement of the latter by their permanent successors appears to begin with the eruption of the last of these, which is followed by those in advance. The first permanent premolar of the upper jaw appears to have protruded after the deciduous teeth, and occupied a position with them in the functional series, but remains after these are shed."

The cranial characters which belong to *Oreodon* as a genus are the following : Orbit completed behind ; temporal fossæ separated by a sagittal crest. A lachrymal fossa, but no facial nor frontal vacuities. Premaxillary bones distinct from each other and from the maxillaries. Nasal bones well developed. Auditory bullæ not inflated.

The preceding dental and cranial characters have been pointed out by Leidy in his various palæontological works. On account of the absence of the necessary material he was unable to give the characters of the remaining parts of the skeleton. These are of course necessary to a correct estimate of the affinities of the genus, and I will endeavor to add such information as my material will permit. This consists of numerous more or less complete skeletons found in connection with the skulls by myself in Colorado in 1873.

Vertebræ. The *cervical* vertebræ are rather short, and the character of the articulation of the centra slightly opisthocoelous, and the articular faces are quite oblique. The axis is the longest vertebra ; the three last centra are subequal in length. In one of my series the seven cervicals are preserved. In all of these, excepting the seventh, the bases of the diapophysis are perforated by the vertebrarterial canal. In the sixth vertebra, the decurved parapophyses are especially robust. The axis and three succeeding centra display strong hypapophyses at their posterior extremities, which are carried forwards as strong median keels. The odontoid process is depressed so as to have a lenticular section ; it is not excavated above, but in my largest specimen the internal borders of the facets for the atlas are continued so as to enclose a short groove on each side at its base. In one smaller and immature specimen this is wanting. The vertebrarterial canal of the axis is enclosed as in the other cervicals. The canal for the second spinal nerve has a narrow roof, but there are no canals

* Ancient Fauna of Nebraska, p. 41.

for the succeeding pairs of nerves perforating the neural arches. The atlas is not very elongate. The base of the diapophysis has a perforating canal, which issues in a large inferior fossa. The vertebrarterial canal then perforates the diapophysis upwards anterior to the middle of the base, and then soon enters the neural canal just posterior to the superior margin of the cotylus of the occipital condyle.

The centra succeeding the cervicals increase gradually in length posteriorly. Those of the anterior part of the dorsal series are quite depressed, but the vertical diameter rapidly increases, so as to be equal to the transverse in some of the lumbars. A trace of the opisthocoelous articulation exists throughout the dorsals but is very little marked in the posterior centra. There are no hypapophyses on the dorsals, but on one of them, probably the third, the inferior and lateral faces are separated by a strong angle, which is strongest anteriorly, giving the articular face a subquadrate outline. The rib-bearing diapophyses are robust. On the posterior dorsals the capitular and tubercular surfaces are confluent, forming a narrow facet on the anterior face of the diapophysis, in a manner not seen in *Cervus elaphus* or *Sus scropha*. The centra of the lumbars, after lengthening, become shorter immediately in front of the sacrum. The vertical diameter of one or two posterior ones is less than that of the anterior ones. The greater number of the lumbars display a small compressed hypapophysis at their anterior extremity; but this is wanting on the posterior ones. The neural arches of the dorsal and lumbar vertebræ are nowhere perforated for the spinal nerves.

The lumbar prezygapophyses embrace the articular faces of the posterior ones, which have a section of one side (below), the end (external), and a half the other side (above), of a transverse ellipse. The superior recurved surface does not appear.

The sacrum consists of five vertebræ, with very depressed centra. The ilium is attached to the diapophysis of the first, and a small anterior portion of that of the second. That of the fourth is flat and free. The anterior zygapophysis of the first displays a slight degree of the superior incurvature general in *Artiodactyla*. The caudal vertebræ were numerous, forming a long tail. The proximal ones are moderately depressed, while more distal ones with wide diapophysis and complete neural arch, are subcylindric, and more elongate. The number of vertebræ preserved in the most complete of my specimens, is as follows :

	Cv.	D.	L.	S.	Cd.
O. culbertsoni ad.	7	5	6	4	4
O. culbertsoni juv.	5	8	6	2	1
O. gracilis	4	5	3	*	*
O. g. coloradoënsis	7	8	6	5	3

An anterior, perhaps second, *sternal segment* is flat and subquadrate in outline, with large hæmal articular face of the lateral margin anteriorly, and a small one posteriorly. No inferior carina.

The spine of the *scapula* rises abruptly from the neck as in Ruminantia, and the coracoid process is short and obtuse. The spine continues to the distal extremity, which is regularly convex.

The most perfect *innominata* in my collection are deficient in the symphysis. The form of the ilium is more that of a hog than of a ruminant. The peduncle is even stouter, and the superior border is abruptly expanded below the middle of the length of the bone. The superior and inferior borders are subparallel as in the hog, and not divergent as in the ruminants. The anterior edge is acute, and uninterrupted by an anterior inferior fossa or spine. The pubis is robust and transverse, and without prominent basal pectineal tuberosity. The incisura acetabuli invades the base of the pubis a little, but the ischium more extensively. The obturator foramen is quite large. The distal border of the ischium is obliquely truncated as in many other Artiodactyla, and more nearly resembles that of the peccary than any other recent form I have observed. The tuber proper is a convex edge, not thickened, and its superior edge is continued into a strong up-looking tuberosity. This region is not so robust as in most recent forms.

The *humerus* of *Oreodon* is readily distinguished from that of recent *Artiodactyla* by several peculiarities. The greater tuberosity is large, rising above the head ; and is incurved, terminating inwards in an acuminate apex. Its border at the base is thrown into an obtuse angle. The lesser tuberosity is small, and is well separated from the greater by a deep and wide bicipital groove. The deltoid ridge is distinct. The condylar extremity is more transversely extended than in any recent Artiodactyle, owing to the fact the posterior interior distal tuberosity is placed interior to the trochlea instead of partially behind it, and that there is, in addition, an internal epicondyle not seen in the recent suilline or ruminant members of the order. The intercondylar ridge is strong, and wider than in most recent ruminants ; in the suillines it has nothing like such a development. Another peculiarity is the flange-like free border of the external trochlea, which is especially recurved at its superior part.

The *radius* is distinct from the ulna throughout. The relation of the ulnar to the radiocarpal surface is posterior as well as exterior; the common suture of the two, making an angle of 45° with the long axis of the radiocarpal surface. The head is a transverse oval, with the inferior face forming a regular curve without notch. Its articular surface is divided into three portions in adaptation to the internal and external humeral trochleæ and the wide median ridge. The external face is beveled forwards above, to fit the flange-like projection of the external trochlea. The shaft of the radius is not very stout, and has a nearly equal transversely oval section to near the distal expansion. Here are wide grooves for the extensor tendons, one superior, the other obliquely exterior. The carpal articular facet has the general ungulate characters. The scaphoid facet is concave above, convex and condyloid below, and is only distinguished from the

lunar facet by a contraction of the anterior and posterior borders. There is no indication of distinguishing ridge between the lunar and cuneiform facets. The posterior border at their junction is prominent, enclosing a fossa with the scaphoid condyle, which does not, however, excavate the intervening surface. The scaphoid condyle is not divided by a ridge.

The *ulna* gradually contracts distally from a robust olecranon. The shaft beyond the humeral cotylus has an oval section, with its long axis forming an angle of 45° to the perpendicular. The olecranon is short and compressed, its posterior border rising nearly as high as the coronoid process. The edges of the humeral cotylus are not flared beyond the shaft.

In the *carpus* the unciform nearly reaches the scaphoid, which is supported by the magnum and trapezium.

The great trochanter of the *femur* is not produced beyond the line of the head, and is well recurved, enclosing a large fossa. The little trochanter is large. The *fossa ligamenti teris* is submedian, subround and large. Distally, the patellar trochlear groove is quite elevated ; its lateral crests are of equal prominence, and nearly equal superior prolongation. The patellar groove is continued some distance above the crests, but there is no fossa in this region as in the hog. The popliteal fossa is well marked, and the condyloid articular surfaces are not entirely cut off from the rotular. The external linea aspera terminates first in a rugose muscular insertion, and then in a shallow fossa a short distance above the condyle. There is no crest nor deep fossa. This element is more like the corresponding one in *Dicotyles torquatus* than in any other mammal. The patella is a short wide bone, with a large anteroposterior diameter. One extremity is acute, the opposite one truncate.

The head of the *tibia* is also like that of *Dicotyles*. The spine is divided as usual, and not much elevated ; the crest is prominent, but is wide and truncate above at the head. It is not excavated as in *Sus*. The external tendinous notch is well marked. The external margin of the shaft does not display any sutural surface for the fibula. The surface of attachment of an external malleolus is distinct. The internal malleolar process is narrow and is produced well downwards. The anterior intertrochlear angle is prominent ; the posterior only convex. The trochleæ are deep, the outer being both the wider and the deeper.

The *astragalus* presents well marked characters. The distal extremity displays the two usual parallel trochleæ, which are separated by a pronounced angle. The cuboid trochlea slopes somewhat backwards, while the navicular is strongly concave. The tibial trochleæ are unequal, the internal being smaller than the external. It is separated from the latter by a constriction which is well rounded and not angulate as in the hog. The external side of the astragalus displays a wide malleolar band, a wide posterior and narrow anterior calcaneal facets, and an undivided concavity intervening between the latter. On the inner side, the malleolar face

descends to below the middle, as in *Hypertragulus*, and there is no vertical nor horizontal distal crest. The inferior calcaneal facet is undivided and not grooved, and does not extend over the internal border of the inferior side of the bone. It exhibits an acute border on the external side. The calcaneum is rather elongate, and the free portion is compressed and with obtuse margins above and below. The transverse astragalar process is not large and is not produced beyond its facet. The ascending plate is well developed and has a superior, uninterrupted convex facet for the fibula, with a narrow facet on its inner side. The inner distal astragalar facet extends the entire length of the cuboid facet. There is a longitudinal ridge on the external side of the distal end of the calcaneum.

The *navicular* and *cuboid* bones are distinct from each other and from the ectocuneiform. The astragalar ligamentous fossa is in the naviculocuboid suture. The inferior proximal angle of the cuboid is produced posteriorly, and the peroneal process well forwards. The ectocuneiform is distinct, and much wider than long. The mesocuneiform is exterioposterior in position, and the transverse diameters are small. It is produced distally, overlapping the head of the second metatarsus. Entocuneiform wanting. The metapodial bones are entirely distinct. The lateral metatarsals are well developed. The second articulates with both the ecto- and mesocuneiform bones, by a proximal extremity which is laterally compressed. The third and fourth are subequal in width, and articulate exclusively with the ectocuneiform and cuboid respectively. The fifth metatarsus is compressed proximally, and the external part of its extremity articulates with a lateral fossa of the cuboid. The distal articular extremities of the metapodials are separated from the anterior face of their shafts by a transverse groove ; and they have a well marked articular fossa on each side. The trochlear tongue only exists on the posterior face, where it is prominent and compressed. It disappears on the middle of the distal end, and is wanting on the anterior face. The phalanges are depressed proximally, the penultimate ones distally also. The ungues are rather depressed and have convex external borders. There is a pair of sesamoid bones below the distal articular extremity of the metatarsals.

History. The dental and cranial characters of this genus were fully described by Dr. Leidy in 1852, as already cited. In the Extinct Mammalia of Dakota and Nebraska, published in 1869, Dr. Leidy added the following points in the osteology of the skeleton of the *Oreodontidæ* (p. 72) : "What are supposed to be the bones of the forearm and leg are discrete, as in the hog, and the bones of the feet correspond in number with those of this animal." In 1873* Prof. Marsh confirmed these statements so far as regards the metacarpal bones, and added that "the navicular and cuboid bones were loosely coössified or separate." The structure of the vertebræ, and of the greater part of the scapular and pelvic arches,

* Amer. Journ. Sci. Arts, p. 409.

with the carpus, tarsus and feet, with the exceptions above noted, are now described for the first time.

This genus appears first in time in the known history of the family, and presents us with its primitive or least specialized characters, or those nearest the average condition of the ordinary primitive ungulate.

Species. The species of this genus are difficult to discriminate from the evidence of crania alone, and their true number will remain uncertain until we can study entire skeletons. My material enables me to make some progress in this direction. After the removal of the forms with inflated bullæ to the genus *Eucrotaphus*, there remain the two species originally referred to Oreodon by Leidy, the *O. culbertsoni* and the *O. gracilis*. To these Leidy subsequently added two others, the *O. affinis*, which is intermediate in size between the two named, and the *O. hybridus*, of larger size than either. As the condition of the otic bullæ in the last is unknown, its generic reference is not certain. All these forms are from the White River epoch of Dakota, Nebraska and Wyoming.

My material is largely from the White River beds of Colorado. I find from this region the true *O. gracilis* and the *O. culbertsoni*, abundantly represented. Besides these there is a form intermediate between the *O. gracilis* and the *O. affinis*, which is nearer the former than the latter. Of *O. gracilis* there are two skulls complete; of the form next larger, which I call *O. gracilis coloradoënsis*, two complete crania (one with skeleton), and a face with teeth. Of a form between the *O. affinis* and the *O. culbertsoni*, there are four skulls complete (two with skeletons); and of *O. culbertsoni* proper, numerous parts of skulls with teeth, but none complete. No other regions which I have explored have produced these species; not even the Ticholeptus beds, where they might have been reasonably expected to occur.

The distinction of the previously known species will remain as Leidy has left it, with certain reservations in the matter of dimensions; while I add two sub-species.

Nasal bones obtuse posteriorly; frontals little produced on either side of them; true molar teeth not exceeding M. .035 in length; canine and premolars .030; width of front .046. *O. gracilis.*

Nasal bones obtuse posteriorly, frontals little produced on either side of them; true molar teeth not exceeding .037 in length; canine and premolars .039; width of front at middle of orbits .046. ..... *O. coloradoënsis.*

Nasal bones obtuse posteriorly, frontals little produced on either side of them; true molar teeth not exceeding .038; front at orbits .057 in width. ..... *O. affinis.*

Nasal bones acute posteriorly; frontal produced to an acute apex on each side of them; molar teeth .040; front, .056. *O. periculorum.*

Nasals and frontals as last; molar teeth .047; front, .050+.. *O. culbertsoni.*

From this table it may be seen that the passage from the small *O. gracilis* to the large *O. culbertsoni* is accomplished by a series of intermediate steps. That these extreme forms belong to one species cannot be admitted without evidence of more complete transition than we yet possess. As above remarked, groups of specimens represent each form and adhere to the definitions given with considerable fidelity. The largest of the specimens I refer to, the form *O. periculorum*, however, reaches .042 in the length of the true molar teeth, and the smallest of the *O. culbertsoni* measures .046. These I must consider as sub-species only. As regards the three remaining forms the length of the true molar series shows a complete gradation. The size of the cranium, as indicated by the interorbital width, is in the *O. affinis* as large as that of the *O. culbertsoni* according to Leidy, and the combination of characters presented by this form, would seem to entitle it to specific rank as suggested by Leidy. On the other hand the form *coloradoënsis* agrees in interorbital width with the small *O. gracilis*, differing from it in the greater length of the muzzle and of the cranium. But here, while the proportions of the premolar teeth distinguish the forms well, the length of the brain-case does not coincide exactly with the other measurements. The measurements of four skulls are as follows: *O. gracilis* No. 1, length of skull M. 114.5; No. 2, .130. *O. coloradonësis* No. 1, .129; No. 2, .135.

Oreodon gracilis Leidy.

Proceedings Academy Philada., 1851, 239; 1853, 392; 1854, 157; 1857, 89; Owen's Report Geolog. Survey, 1852, 550, Pl. XI, figs. 2–3; Pl. XIII, figs. 5–6. Ancient Fauna Nebraska 1853, p. 53, Pl. V, figs. 3–4; VI, figs. 1–7. Extinct Fauna Dakota and Nebraska, 1869, 94, Pl. VI, figs. 2–3.

Abundant in the White River beds of Dakota, Nebraska, Colorado and Wyoming.

The two sub-species are distinguished as follows:

Length of superior premolar series, M. .023..... *O. g. gracilis*
Length of superior premolar series, M. .029..... *O. g. coloradoënsis.*

Oreodon gracilis gracilis Leidy.

Dakota, Nebraska and Colorado.

Oreodon gracilis coloradoënsis Cope.

Colorado.

Oreodon affinis Leidy.

Extinct Mammalia Dakota and Nebraska, p. 105; Pl. IX, fig. 3.

Probably from the White River beds of Nebraska.

Oreodon culbertsoni Leidy.

Owen's Report Geological Survey, 1852, 548, Pl. X, figs. 4–6; XIII, figs. 3–4; Ancient Fauna Nebraska, Smithsonian Contrib. to Knowledge, 1853, 45; Pl. II, III, IV, figs. 1–5, V, figs. 1–2, VI, figs. 8–11; Proceeds.

Academy Philada., 1853, 392; 1854, 35, 157; 1857, 89; Bronn Lethæa Geognostica, 1856, 930. Extinct Fauna Dakota and Nebraska, 1869, p .86; Pl. VI, fig. 1; VII fig. 2; IX, figs. 1–2. *Merycoidodon culbertsoni* Leidy, Proceeds. Acad. Phila., 1848, 47, Pl. II; 1850, 121; 1851, 239. *Oreodon priscum* Leidy, Proceed. Phila., Academy 1851, 238; *Cotylops speciosa* Leidy, Ibidem 239; *Oreodon robustum* Leidy, Ibidem 276.

The White River epoch of Dakota, Nebraska, Colorado and Wyoming.

The two sub-species are defined as follows:

Length of superior true molar series from M. .040 to .042. ..... *O. c. periculorum.*

Length of superior true molar series from .046 to .050.... *O. c. culbertsoni.*

Oreodon culbertsoni periculorum Cope.

This smaller race or sub-species has as yet only been found in the White River beds of Colorado and Wyoming. I do not detect any differences between it and the Nebraska form other than those of size. The largest measurement of the *O. c. culbertsoni* given in the above table is derived from Leidy; my largest specimen gives .047 as the length of the true molar series.

Oreodon culbertsoni culbertsoni Leidy.

Very abundant in the White River formation of Dakota, Nebraska, Colorado and Wyoming.

EUCROTAPHUS Leidy.

Proceedings Academy Philada., 1850, p. 92. Ancient Fauna of Nebraska, Smithsonian Contrib. to Knowledge, 1853, p. 56. *Eporeodon* Marsh, Amer. Journ. Sci. Arts, Vol. ix, 1875, p. 249.

Premaxillary bones distinct from each other. Otic bulla swollen. No prelachrymal or nasal vacuities.

This genus presents us with the first step in the series of modifications which the primitive form underwent with the advance of geological time. It appeared contemporaneously with the earliest representatives of the family, *i. e.*, in the White River epoch, but in small numbers. In the succeeding or John Day epoch the genus Oreodon had disappeared, and the present form had multiplied enormously in individuals, if not in species. Subsequent to that epoch it is unknown.

The greater number of the Oreodont remains found in Oregon belong to this genus. The *Eucrotaphus jacksoni* bore the same relation to the Oregon John Day fauna, as the *Oreodon culbertsoni* did to that of the White River epoch.

The species of Eucrotaphus are distinguished as follows:

I. Palatonareal border well posterior to posterior edge of maxillary bones.

a. Infraorbital foramen above front of P-m. iii.

Skull depressed, muzzle short; paroccipital process behind bulla and not separated from it by grooves; bulla grooved to apex for styloid ligament, etc.; zygoma more robust. *E. trigonocephalus.*

II. Palatonareal border in line with posterior edges of maxillary bones.

aa. Infraorbital foramen above posterior part of third premolar.

Paroccipital process behind otic bulla, the internal border of its base opposite that of the bulla. ..... *E. jacksoni.*

Paroccipital process external to the middle of the otic bulla; generally larger. ..... *E. major.*

The name here employed for this genus is the one first given with a definition. The typical species, *E. jacksoni*, was widely distributed, and appears under several varietal forms and sizes, some of which have received names. Subsequently to the original description, Dr. Leidy added to the genus a second species, which probably belongs to the genus Agriochœrus. On this account Leidy inclined at one time to combine the two genera, but afterwards abandoned the idea.

Eucrotaphus trigonocephalus, sp. nov.

This distinct form is only known to me from a single skull of an old animal. In the character of its otic bulla it has resemblance to the species of Agriochœrus, while the maxillary part of the skull has the posterior position of a true Oreodon.

The muzzle is rather depressed, and the premaxillary alveolar border is almost transverse. The position of the canine alveolus is swollen laterally, and between it and the infraorbital foramen the side of the face is slightly concave. The expansion leading to the malar bone commences as the posterior slope of the concavity mentioned, and spreads laterally, without interruption, beginning to project beyond the superior alveolar border at the fourth superior premolar. In the *E. jacksoni* this is not apparent anterior to the first true molar. The top of the muzzle and the front are wider than in that species, and are gently concave in the transverse direction. The anterior temporal ridges are well defined, and concave in outline, uniting early to form a prominent sagittal crest. The malar bone is a little concave below the orbit. The malar process of the maxillary projects downwards in an obtuse angle, opposite the penultimate superior molar. In *E. jacksoni* the malar is convex, and the tuberosity is opposite the last molar. The squamosal process is deeper than in the *E. jacksoni*, and sends a more robust apex into the malar bone, the apex not extending in front of the posterior border of the orbit. The supraoccipital crests are well developed, and project beyond the vertical plane of the condyles; they continue into well marked posttemporal crests, as in the other species of the genus, as well as send an obtuse ridge downwards on each side towards the foramen magnum. The median supraoccipital plane disappears downwards in a wedge-shaped apex, which causes the transverse section

above the foramen magnum to be obtuse angulate instead of broadly flattened as in *E. jacksoni*. The mastoid crests are roughened and are vertical, but do not continue directly into the paroccipital processes, but are separated from them by a deep excavation of the external margin, due to the internal position of the base of the process.

The long diameter of the base of the paroccipital process runs outwards and backwards, and it is attached to the bulla at the middle of the posterior extremity without any intervening grooves such as are seen in the other species of the genus. The bullæ are ovoidal in anteroposterior section, the regularity interrupted, however, by the presence of a ridge on the external side directed posteriorly, enclosing a groove which is continuous with the stylohyoid fossa. The ridge continues into the inferior crest of the tympanic bone. The sphenoid bone is regularly convex in transverse section, while the basioccipital is concave on each side with a narrow median keel, which commences opposite the anterior edge of the paroccipital processes. The basicranial axis is not quite in line with the basifacial, but does not present such an angle with it as is seen in the species of Merycochœrus, where the skull is known to me. In this respect it agrees with the other species of the genus. The postglenoid processes are less prominent than in *E. jacksoni*, but have a base more widely extended outwards. The external border is very oblique, since the apex is narrowed. The glenoid region is more extended, both transversely and anteroposteriorly than in the *E jacksoni*. The anterior border is continued as an alisphenoid angle which becomes prominent, and overhangs the foramen rotundum. The descending alisphenoid ridge commences within the anterior border of the foramen ovale. The pterygoid angle is anterior to the middle of the palatosphenoid wall of the nareal foramen, and in front of it the edge of the processus pyramidalis is marked by a shallow fossa or mark of insertion of the internal pterygoid muscle. The nareopalatal border is as far posterior to the line connecting the posterior edges of the maxillaries as the width of the second molar tooth. The palate is everywhere nearly flat. The malar bones spread well away from the maxillaries on each side, the anterior border of the zygomatic foramen being a segment of a circle. The squamosal part of the zygoma is more widely expanded than the malar part. In *E. jacksoni* the shape of the zygomatic foramen is quite different. Its anterior outline is interrupted by the projection of the maxillary bone posteriorly, which gives its anterior outline a bilobate form. It is longer than wide in that species, and wider than long in the *E. trigonocephalus*.

The infraorbital foramen is small. There are two lachrymal foramina; one larger, within the preorbital border, the other smaller, below the tuberosity on the rim of the orbit. The frontal foramina are separated by a space equal to one-fourth the entire frontal width. The supraorbital notches are wanting. The preorbital fossæ are well marked, are distinctly defined above, and extend as far as the anterior border of the lachrymal bone. The orbit is round, and looks upwards as well as outwards and

forwards, on account of the prominence of the zygomatic arch. There are two postparietal foramina, one below and behind, the other on the parieto-squamosal suture. The mastoid foramen is not small. The incisive foramina are large, are longer than wide, and are separated by a rather wide isthmus. The palatine foramina are opposite the third premolars. There is a foramen immediately below the postfrontal process. The optic foramen issues posterior to the line of the posterior border of the orbit, and in front of the anteroinferior angle of the alisphenoid. The foramen rotundum is large and round, and is immediately below and within the ridge above mentioned, and is not overhung by a transverse ridge of the same, as in the species of Meryeochœrus known to me. The f. rotundum doubtless includes the f. sphenoörbitale. The f. ovale is smaller and is separated by a considerable interval from the f. lacerum. The latter is subtriangular in form and is rather small, since the base of the otic bulla is in close sutural contact with the sphenoid and basioccipital for a considerable distance. The f. jugulare is subtriangular in outline and is smaller than the f. rotundum. It is entirely distinct from the f. condyloideum, which is the size of the f. ovale. No f. supraglenoideum. In comparing these foramina with those of the *E. jacksoni*, a general resemblance is to be seen. The frontal foramina in that species are *generally* closer together than in *E. trigonocephalus*, and the palatine foramen is *generally* opposite the fourth premolar instead of the third. The foramen magnum is slightly notched on its superior border in both.

The posterior outline of the nasal bones is truncate; it is more or less acuminate in all the specimens of *E. jacksoni* and *E. major* accessible to me. The prolongation of the frontal on either side of the nasals is also short and truncate in this species, and narrow and acuminate in the *E. jacksoni* and *E. major*. The lachrymal is deeper than long; in the species last named it is of variable size and form, but is usually as long as deep. There is no distinct ridge along the parieto-squamosal suture. The alisphenoid has a considerable contact with the pariëtal. The palatomaxillary suture is irregularly convex backwards on each side of the median line. It crosses the palate as in the *E. jacksoni*, at the front of the second maxillary tooth.

The teeth are much worn, and the first and last true molars with several of the premolars have been lost, indicating the age of the animal. The incisors are small and have round roots. The canines are large and of the usual form. The space between them and the first premolar is short. The fourth premolar is small. The second true molar is wider than long, and has no internal cingulum except between the lobes, and has a trace of anterior cingulum.

Measurements.	M.
Axial length from occipital condyles to premaxillary border	.187
Axial length from occipital condyles to postglenoid process	.031

Measurements.	M.
Axial length from occipital condyle to postfrontal process	.076
Axial length from occipital condyle to palatonareal border	.079
Axial length from occipital condyle to end of last molar	.091
Diameters of orbit { vertical	.031
Diameters of orbit { horizontal	.027
Depth malar bone at middle of orbit	.016
" zygomatic process posteriorly to glenoid face	.028
" skull (right angles to profile) at glenoid face	.045
" " " " orbit	.046
" " " " P-m. i	.030
Elevation of occiput from foramen magnum	.044
Width top of muzzle at preorbital fossæ	.040
" at middle of supraorbital border	.059
" " postfrontal process	.075
" " malar below orbit	.110
" " zygomatic process of squamosal	.145
" of occiput at condyles	.066
" " occipital condyles	.039
" " palate at palatonareal foramen	.028
" " " at M. ii	.032
" " " " canines	.030
Length of superior dental series with canines	.088
" " premolar series	.047
" " true molar series	.036
Diameters canine at base { anteroposterior	.009
Diameters canine at base { transverse	.010
Diameters P-m. iv. { anteroposterior	.009
Diameters P-m. iv. { transverse	.013
Diameters M. ii. { anteroposterior	.014
Diameters M. ii. { transverse	.018

The typical specimen of this species was found by Charles H. Sternberg on the North Fork of the John Day river. The horizon is probably somewhat different from that of the true John Day epoch.

Eucrotaphus jacksoni Leidy.

Proceedings Academy Philadelphia, 1850, p. 92. Ancient Fauna of Nebraska, Smithsonian Contributions to Knowledge, 1852, p. 56, Plate VII, figs. 4–6. *Oreodon bullatus* Leidy, Extinct Mamm., Dakota and Nebraska, 1869, p. 106. Report U. S. Geol. Survey, Terrs. 1873, I, p. 318. *Oreodon occidentalis* Marsh, Amer. Journal Sci. Arts, 1873 (May), p. 409. *Eporeodon occidentalis* Marsh, Loc. cit., 1875, p. 250. *Eucrotaphus occidentalis* Cope, Bulletin U. S. Geol. Survey Terrs., V, p. 59.

Comparison of numbers of crania from the White river and John Day

formations fails to reveal any characters distinguishing them as more than one species. In fact the variation in various respects is greater among the individuals of the John Day epoch, than between those of the two epochs. This was by far the most abundant mammal of the John Day epoch while it appears to have been rare during that of the White River.

Specimens differ in the size of the preorbital fossa irrespective of other differences. In some specimens it is wide and profound, including the lachrymal bone; in others it is less extensive and is shallow, involving but part of the lachrymal. It is never wanting or obscure. For estimation of other characters, I select ten crania, nine from Oregon and one from Dakota, as expressing the greatest range of variation. Of these, three display a peculiarity in the form of the otic bulla. Instead of being contracted backwards in front, it is protuberant and full at its inferior anterior part. Five other crania, agreeing with these three in other respects, possess the normal form of bulla. In one cranium, which is rather more robust than the others, the infraorbital foramen is a little posterior to its usual position, being above the anterior part of the fourth premolar. This tooth is also distinctly smaller than in other specimens of otherwise similar dimensions. The majority of specimens range nearly alike in dimensions, but there are forms distinctly larger and smaller, which may represent distinct species. This question can be better decided when the skeletons are known. I give three sub-species which are defined as follows:

Length of cranium M. .197; of molar series M. .086; long diameter of base of paroccipital process transverse; its posterior base flat..... *E. j. jacksoni.*

Length of cranium M. .219; of molar series M. .091; paroccipital process as above.....*E. j. pacificus.*

Length of cranium, M. .235; of molar series, M. .099; paroccipital process strongly compressed, its posterior base angulate on the middle line.....*E. j. leptacanthus.*

The above measurements of length are made from the occipital condyles to the premaxillary border inclusive.

The three forms may represent good species. The *E. j. jacksoni* is of the size of the *Oreodon culbertsoni;* the *E. j. leptacanthus* is larger than the *E. major,* while the *E. j. pacificus* is intermediate between the two.

Eucrotaphus jacksoni jacksoni Leidy.

The typical specimen of the *Oreodon bullatus* Leidy agrees so nearly with the original type of *Eucrotaphus jacksoni,* that I cannot doubt their pertinence to the same species. There are two specimens in the collection of the Philadelphia Academy, besides the last named, and at least one in the museum at Princeton. A specimen from the John Day, Oregon, cannot be distinguished from these. It agrees with Marsh's measurements and description of his *Oreodon occidentalis,* and no doubt represents it. Its

identity with his *O. bullatus* has already been surmised by Leidy (Report U. S. Geol. Survey Terrs., I, p. 318).

Eucrotaphus jacksoni pacificus Cope.

This form is materially larger than the last named, equaling in dimensions and resembling in general form the *Eucrotaphus major* Leidy, of the White River beds. It is no doubt the form which has been identified under that name by Leidy in his report on John Day Fossils in the Report of the U. S. Geological Survey of the Territories, Vol. I. It is different from that animal in the form and position of the paroccipital process, as already pointed out. I have eight crania disengaged from the matrix which agree in dimensions and other characters assigned to this sub-species. In one of them the paroccipital process presents an approach to the form of that of the *E. j. leptacanthus*. A specimen from the White Buttes of Central Dakota agrees with those from Oregon in all the essential characters, and is the second one of the sub-species I have seen which is not Oregonian. I have many crania of this sub-species not yet entirely cleared of matrix.

From John Day river and Crooked river, Oregon ; C. H. Sternberg and J. L. Wortman ; White river of Nebraska, Mus. Princeton.

Eucrotaphus jacksoni leptacanthus Cope.

This is the largest form of the genus, exceeding the typical *E. major* in the length of the skull by 23 mm. It is thus far represented in my collection by two very perfect crania. There is considerable reason for anticipating that this form will turn out to be a valid species. Besides the peculiar form of the paroccipital processes, the typical specimen presents the following characters :

The frontal region is flatter than in the two other sub-species, and is concave on the median line in transverse section. This concavity is probably partly abnormal. The profile of the sagittal crest instead of presenting a gently convex outline, is concave, rising posteriorly. The lateral occipital crests instead of being angulate are truncate behind, and the inferior angle projects much beyond the vertical line of the occipital condyles. As this part is broken off in most of my specimens of the *E. j. pacificus*, I cannot decide as to its value. The inferior carina of the tympanic bone extends forwards to contact with the internal extremity of the postglenoid process. It does the same in the Oregon specimen of *E. j. jacksoni*, and in the Dakota specimen of the *E. j. pacificus*. In two of the latter, from Oregon, where the part is cleaned, the keel does not extend so far forwards or inwards.

The typical specimen is from the John Day beds of John Day river, Oregon, and was found by Jacob L. Wortman.

Eucrotaphus major Leidy.

Oreodon major Leidy, Ancient Fauna of Nebraska, 1853, p. 55, Pl. IV, fig. 6. Proceedings Academy Philadelphia, 1853, 398 ; 1856, 164 ; 1857, 89.

Extinct Mammalia, Dakota and Nebraska, 1869, p. 99, Pl. VII, fig. 1; VIII. *Eporeodon major* Marsh, Am. Journ. Sci. Arts, 1875, p. 250.

I find this species to differ in the external position of the paroccipital process, as related to the otic bulla, from the *E. jacksoni*. I might add that it differs in dimensions from all excepting the *E. jacksoni pacificus*. In the *E. jacksoni* the base of the paroccipital process is in the same line as the interior base of the otic bulla. In the Oregon form of the *E. major* the base of the paroccipital process is much flattened, so as to be transverse, and its internal border is on the external side of the extremity of the large swollen bulla. This species differs also from the *E. jacksoni* in the median vertical carina of the occipital bone above the foramen magnum, a region which is in the *E. jacksoni* broadly flattened. Besides these points I do not notice any divergence from the *E. jacksoni*, with which it agrees in the various characters in which the latter differs from the *E. trigonocephalus*.

The Nebraska and Oregon forms do not agree in all respects. Thus, while the dimensions of the dental series are the same in both, the frontal region is more elongate in the Oregon animal, giving greater length to the skull. The third superior premolar has a somewhat different form in the two. They may then be characterized as follows:

Dental series M. .125; skull .224; third superior premolar, subtriangular.....*E. m. major.*

Dental series M. .125; skull .240; third superior premolar subquadrate.....*E. m. longifrons.*

Eucrotaphus major major Leidy.

Known only as yet from the White River epoch of Nebraska and Dakota.

Eucrotaphus major longifrons Cope.

Known from a single skull from the North Fork of the John Day river, Oregon, found by Charles H. Sternberg. It may be observed here that the Oreodontidæ of this locality are mostly distinct from the species of the John Day river proper.

MERYCOCHŒRUS Leidy.

Report U. S. Geol. Survey Terrs., I, 1873, p. 202. Bettany, Quart. Journ. Geol. Soc. London, 1876, p. 262; Cope, American Naturalist, 1884, p. 281. Leidy, Extinct Mammalia of Dakota and Nebraska, 1869, p. 110 (nomen nudum). Proceedings Academy Philadelphia, 1858, p. 24 (nomen nudum).

As indicated in the analytical table at the head of this article, I can only distinguish this genus from *Eucrotaphus* by the confluence of the premaxillary bones. The position of the external infraorbital foramen cannot be regarded as furnishing generic characters, especially as it displays considerable variation and gradation. Some of the species are in this respect quite identical with species of Merychyus (*M. superbus*), while others

possess the widely different position ascribed to this genus by Leidy. Few if any of the characters given by Mr. Bettany as those of the genus, can be regarded as other than characters common to several of its species. Perhaps the most important of these is the angle formed by the basifacial with the basicranial axis, by which the face is presented as much forwards as upwards. The species present considerable variety in form. The genus embraces the largest species of the family, such as *M. macrostegus*, *M. superbus*, etc. The characters of the species are as follows:

I. Foramen infraorbitale above middle of fourth superior premolar; posterior part of zygoma expanded; palate moderately produced posteriorly.

Squamosal part of zygoma less expanded anteriorly and with rounded border; head elongated; premaxillary bone not produced; otic bulla larger, compressed, extending anterior to postglenoid process; size large ..... *M. superbus.*

Head shortened occipitally, so that a line drawn through postglenoid and paroccipital processes makes 90° with the middle line; malar bone openly grooved below orbit; angle of mandible obliquely truncate. ..... *M. leidyi.*

Squamosal part of zygoma most expanded in front, and elevated behind, so that the cranium is as wide as from the paroccipital process to the canine tooth; its posterior angle rising to a level with the sagittal crest; its inferior edge spread outwards; its superior edge truncated; occiput not shortened; malar flat below orbit; postglenoid process marking front of bulla..... *M. chelydra.*

II. Foramen infraorbitale above the first true molar. Palate greatly produced posteriorly.

Squamosal part of zygoma much expanded, and with truncate edge; malar bone robust, prominent; skull, width equal length from condyles to first premolar; maxillary produced anteriorly; frontal plane, transverse diamond-shaped; bulla small, conical, posterior to anterior edge of postglenoid process..... *M. macrostegus.*

Squamosal part of zygoma little expanded upwards or laterally, edge rounded; malar bone flat; bulla large, extending in front of postglenoid process; front longitudinally diamond-shaped, decurved at orbit..... *M. montanus.*

III. Foramen infraorbitale above anterior border of second true molar.

Zygoma originating above second molar; large; incisors small (fide Leidy). ..... *M. rusticus.*

Zygoma originating above third true molar; larger; incisors large (fide Leidy). ..... *M. proprius.*

Of the above seven species, four are represented in my collection, some of them by a large amount of material. The latter are from the John

Day and Ticholeptus Miocene horizons. The *M. rusticus* of Leidy is only known to me from the descriptions of that author. It is from the Sweetwater river, Wyoming, from a bed of probably Ticholeptus age. The *M. proprius* Leidy, also unknown to me by autopsy, is from the head of the Niobrara river, Nebraska, from a bed said by Hayden to be intermediate between the Oreodon or White River and Procamelus, or Loup Fork horizons, and therefore probably of Ticholeptus age also. The *M. leidyi* I only know from the description of Mr. Bettany. It is from the John Day beds. Mr. Bettany also describes an *M. temporalis*, which I cannot distinguish from the *M. superbus* Leidy.

Merycochœrus superbus Leidy.

Oreodon superbus Leidy, Proceedings Academy Philadelphia, 1870, p. 109. Extinct Mam. fauna, Dakota and Nebraska, 1869, p. 211; Plate I, fig. 1; II, fig. 16; VII, figs. 7–11. *M. temporalis* Bettany, Quar. Journ. Geol. Soc., London, 1876, xxii, p. 269; Pl. XVII.

Of this fine species I have nine crania extracted from the matrix, and a good many not yet cleaned. As the specimen described by Leidy is in a very imperfect condition, the characters of the species, and even its generic position, have remained hitherto very obscure.

As compared with the allied species, the *M. superbus* is slightly exceeded in size by the *M. macrostegus* and *M. montanus*. Its posterior zygomatic expansion is less pronounced than in the *M. macrostegus* and *M. chelydra*, and its border is rounded, even when, as is sometimes the case, it is greatly thickened. In the first and last named of the above species, its border is separated by a distinct angle from both the internal and external faces, forming thus a distinct truncate face which looks upwards. The otic bulla is larger than in the two species mentioned, and extends anterior to the postglenoid process. The nareal fissure extends well down towards the alveolar border of the premaxillaries, which are therefore more extensively separated than Leidy represents to be the case in the *M. rusticus*. The external face of the malar bone below the orbits is flat. The anterior extremity of the zygomatic process is not so prominent as in *M. chelydra*, and is rounded instead of being flared out below, as in that species. The greatest width of the skull is at the glenoid surfaces, and not anterior to them, as in *M. chelydra*. In only one of seven crania, where the parts are preserved, does the posterior squamosal angle rise as high as the sagittal crest.

I cannot detect any difference between the specimen described by Mr. Bettany as the type of his *M. temporalis*, and those of the *M. superbus* in my possession. The shallowness of the preorbital fossa described by Mr. Bettany is repeated in one of my crania, and its depth is very variable in the others. As regards the *M. leidyi* of Bettany, I have none exactly like it, although the type specimen does not differ much from the *M. superbus*, to judge from the figure and description given in the Quarterly Journal of the Geological Society, 1876, p. 270. The two distinctive

characters, which appear most tangible among those mentioned by Mr. Bettany, the shortness of the occipital region, as measured by the angle made by a line drawn through the postglenoid and paroccipital processes, with the middle line, and second, the grooved character of the suborbital part of the malar bone, are not found in any of my specimens of *M. superbus*. The anterior extremity of the squamosal process of the zygoma is protuberant in one of them, as in the *M. leidyi*. Another character is suggested by Mr. Bettany's figure, but is not mentioned in the text. The angular border of the mandibular ramus extends obliquely forwards instead of being prominently convex as in the best preserved entire mandible of the *M. superbus* in my possession. Nevertheless in another specimen, where a good deal of the posterior border is preserved, the outline is nearly as oblique as in the *M. leidyi*. The species, however, is distinct so far as now known.

John Day epoch, Oregon, C. H. Sternberg and J. L. Wortman. Localities, John Day river, Bridge creek, and Camp creek of Crooked river.

Merycochœrus leidyi Bettany.

Quarterly Journal of the Geological Society of London, xxxi, 1875, p. 270; Plate XVIII.

Defined and discussed under the preceding species.

John Day epoch, Oregon; Lord Walsingham. John Day river.

Merycochœrus chelydra, sp. nov.

This species is known to me by a skull without mandible, which is entire, except that the extremity of the nasals and the border of the premaxillary bones are broken off. It is unfortunate that I have no second skull to confirm its characters, but my numerous specimens of the *M. superbus*, to which it is most nearly allied, do not present any approximations which suggest transitions between the two.

The striking character of this cranium is its great breadth at the temporal region, as compared with its length and other dimensions. The forms of the otic bulla differ from those of the *M. superbus*. One method of expressing the width of the skull is as follows. The point of the frontal bone which is equidistant from the supraoccipital notch and the external edge of the zygomatic arch, measured in a horizontal plane, is directly above the posterior or nareal palatal border, when the skull rests on the teeth. In the *M. superbus*, in the most robust examples, this point is above a point which is a good deal nearer to the line of the anterior edge of the glenoid surfaces than to the palatal border, and at least 30mm. posterior to the latter. That this relative shortness of the basicranial axis is not due to a shortening posterior to the glenoid surfaces, as is the case in *M. leidyi* Bett., is proven by the fact that a line drawn through the postglenoid and paroccipital process makes an angle of 90° with the middle line, as in *M. superbus*.

The muzzle is compressed and its superior surface is regularly rounded

The side is divided by the gentle convexity continued forwards from the malar region. Below this and above the premolars the face is concave. Above it the preorbital fossa is well marked, though not deep, and gradually fades out anteriorly. The interorbital region is flat, as in *M. macrostegus*, and the supraorbital border is not decurved, as it is in *M. superbus* and *M. montanus*. The supraorbital and preorbital borders of the front are, however, not continuous as in *M. macrostegus*, though nearly in the same line, which they are not in *M. superbus*. The orbits are more oblique than in *M. superbus*, looking more upwards and forwards, and their vertical exceeds their transverse diameter. The malar bone though oblique, is more vertical than the orbit below the latter, and has an uninterrupted gently concave surface. The postorbital bridge is narrow, and consists one-half of the malar and one-half of the frontal bones. The inferior edge of the malar is thin and is slightly convex downwards, and passes behind the protuberant squamosal at a point behind the line of the postfrontal process. The anterior extremity of the squamosal is not protuberant below the orbit and only begins to rise gradually below the line of the postfrontal process. It then expands rapidly downwards and outwards in a strong curve, with its flat surface looking upwards as much as outwards. After making a short downward turn it rises steeply, contracting gradually inwards, and presenting a convexity posteriorly, with its truncate edge looking outwards. Its apex is nearly on a level with the sagittal crest. The inner or descending edge of this process is concave, so that the apex overhangs a little the posterior outlet of the temporal fossa. The anterior temporal angles are strongly marked and unite into a sagittal crest. The edge of the crest is thickened, so that its section is a letter T.

The supraoccipital bone presents a wide flat convexity above the foramen magnum, in distinction from the stronger convexity of *M. superbus*, and the still stronger of the *M. macrostegus* and *M. montanus*. As in the other species, the posttemporal (= lateral occipital) crests are only present at the upper half of the occiput. Between them there are two ligamentous or tendinous insertions, but no median keel. The exoccipital and posttympanic borders form a tuberosity below the meatus auditorius, which passes upwards into a short convex posttemporal crest. The paroccipital process nearly reaches the postglenoid by its anterior external edge. The tympanic is complete, is not keeled below, and extends itself as a lamina over the posterior side of the postglenoid process. The section of the basioccipital is open V-shaped. The inferior flat surface of the sphenoid is produced backwards in a wedge-shaped prominence to a line connecting the anterior edges of the paroccipital processes. It has the same form in *M. macrostegus*, but in three skulls of *M. superbus*, where it is visible, the apex of the wedge does not extend posterior to the middle of the otic bullæ. The bullæ are small and subconical, and reach as far as the anterior edge of the postglenoid process. In the latter the transverse diameter exceeds the anteroposterior, which exceeds the vertical diameter. This process and the otic bulla are of about equal protuberance. In four

crania of the *M. superbus*, where both are well preserved and exposed, the bulla is considerably more prominent than the postglenoid process. The glenoid surface is well-defined and equally wide at both extremities. The inferiorly presented surface of the zygomatic arch, is wider than in any of the other species, including examples of *M. superbus* of superior dimensions in other respects. The surface is rugose. The length from a line connecting the median external columns of the last superior molar, to the posterior nareal border, enters three times into the distance from the latter to the border of the foramen magnum. In *M. superbus* it goes three to three and a half times; in *M. macrostegus* and *M. montanus* once only. Behind the molars the produced palatal roof is more concave than between the last two true molars. The palate becomes then more concave (convex), and between the first premolars and canines becomes flat, and expands laterally. The nareal fissure is not much contracted between the premaxilliaries.

The infraorbital foramen is above the anterior half of the superior fourth premolar, and is of moderate size. The frontal foramina are separated by a space which is less than half as wide as that which separates each one from the superciliary border. There is no supraorbital notch. The incisive foramina are large, are wider than long, and approach close to the bases of the canine teeth. The palatine foramina are minute or obsolete. The foramen ovale is isolated and is opposite the junction of the glenoid and postglenoid surfaces. The jugular foramen is isolated by the extensive contact of the otic bulla and the basicranial axis. Perhaps the condyloid foramen is included in it, as I do not find it in the usual position. The animal is so old that no sutures are visible.

The teeth are not all cleared from the matrix, which is hard and brittle. The first true molar is much worn. The first premolar is two-rooted, and is separated from the canine by a diastema equal in length to the long diameter of its crown.

Measurements.	M.
Length from occipital condyle to front of canine tooth.	.300
" " " " " postglenoid process...	.041
" " " " " postfrontal process. ..	.132
" " " " " palatonareal border ..	.118
" " " " " end of last molar.....	.146
Diameters of orbit { vertical.....	.0455
Diameters of orbit { transverse.....	.039
Depth of malar bone at middle of orbit.....	.034
" " zygomatic process to glenoid face behind.....	.088
Width of top of muzzle at preorbital fossa	.043
" at middle of supraorbital border.....	.094
" " malar below orbit.....	.160
" " middle of zygomatic arch.	.254
" of occiput at superior crests.....	050

Measurements.	M.
Elevation of occiput from foramen	.084
Width of occipital condyles	.063
Width of occiput at condyles	.095
Depth of skull at right angles to profile at glenoid face	.095
" " " " " " orbit	.087
" " " " " " P-m 1	.075
Length of superior dental series with canine	.159
" " premolar series	.061
" " true molar series	.065
Diameters M. i { anteroposterior	.0180
Diameters M. i { transverse	.0185
Diameters of canine { anteroposterior	.016
Diameters of canine { transverse	.020
Diameters P-m. ii { anteroposterior	.0155
Diameters P-m. ii { transverse	.090
Width of palate at m. i	.044
" " P-m. i	.057

The typical specimen was found on the John Day river, Oregon, by Mr. J. L. Wortman.

Merycochœrus macrostegus, sp. nov.

I have been able to discover in my collection as yet, but one cranium with entire mandible of this species. The very marked characters of this skull are such that no farther evidence of its reference to a peculiar species is needed. Its affinities, as expressed in the analytical key which accompanies the general discussion of this genus, are with the *M. montanus.* This is shown in the posterior positions of the infraorbital foramen, and of the posterior nares. As peculiar characters may be added the form of the frontal plane and of the otic bulla ; also the prolongation of both the premaxillary and supraoccipital regions, and the forms of the zygoma, the angle of the mandible, and the first inferior premolar tooth. The skull reaches a greater length than that of any species, excepting the *M. montanus,* but is not nearly so robust as in the *M. chelydra,* resembling in this respect rather the *M. superbus.*

The muzzle is compressed, and there is a decided concavity just above the second premolar, above which the surface is a little convex. Above the infraorbital foramen, the face is abruptly convex, the convexity sloping upwards to the base of the median ridge formed by the convex nasal bones. Behind this the side of the face is a plane which slopes outwards as it descends, which is only interrupted by the rather small, but well defined, preorbital fossa. The fossa is better defined in front than in the other species, but I do not know whether the character is constant. The front is a transverse diamond-shaped area, bounded posteriorly by the anterior temporal ridges, and anteriorly by the lines of the supraorbital borders

produced to their point of intersection with each other. Such point of intersection is above the second true molar in this species ; in *M. superbus* and *M. chelydra* it is above the posterior part of the second premolar. The area in these species enclosed by the lines in question is half as long again as wide, instead of wider than long by 18mm. This difference is partly caused by the greater prominence and flatness of the postorbital angle of the frontal bone in the *M. macrosteyus*, and the more anterior direction of the orbits, which I may add have none of the tendency to superior direction seen in *M. chelydra*. The wide triangular area thus enclosed on its external sides by the orbit and anterior temporal ridges, is perfectly flat. Such an area can hardly be defined in the other species, and the surface there is rounded and descending. The malar bone is deep, flat and a little oblique outwards, and the rim of the orbit projects a little, giving it a slight concavity. The orbit is deeper than wide. The anterior part of the zygomatic process of the squamosal is not protuberant below the orbit, but gradually rises outwards posteriorly, attaining its greatest expansion opposite the middle of the zygomatic foramen ; above, its course is for a time parallel with the middle line of the skull. The form of the zygomatic arch is more like that of *M. chelydra* than any other species, but it is not so much expanded, especially anteriorly. Its inferior and posterior surface is, however, widened, making an angle with the external or marginal surface, which is in turn separated by an angle from the superior and anterior surface ; at the middle of the arch the superior surface has a width of 19mm., and the external a width of 23mm. The posterior angle rises to the plane of the summit of the sagittal crest, and the apex, which is less than a right angle, stands above the external base of the postglenoid process. The preglenoid border is not exactly at right angles with the middle line, but makes a slight angle outwards and forwards. The long diameter of the zygomatic foramen is parallel with it. The ridge along the pariëtosquamosal suture is insignificent. The supraoccipital region is very prominent, and as in the other species of this genus is narrowed below by the disappearance of the posterior temporal or exoccipital crests. They are continued downwards and disappear, leaving a wide convex surface above the foramen magnum. This is separated by the usual lateral fossa from the posterior temporal angles.

The coössified mastoid and paroccipital processes much contract the auricular fossa below, but do not close it. The latter is contracted at the base of its terminal part, and is distally slender. The otic bulla is the smallest known in the genus, it is compressed and oval, and not produced beyond the postglenoid processes either forwards, backwards or downwards, in this differing much from the *M. montanus*. It is separated by wide and equal intervals from this process, the glenoid surface, and the basisphenoid. It sends a process backwards and inwards to a sutural junction with the basioccipital bone. The tympanic bone is flat below, and is united with the posterior base of the squamosal by a flat expansion. The postglenoid process is robust, and has the height and thickness equal,

while the width exceeds both. The basioccipital bone is prominently keeled on the middle line, so that the section is a V of a more compressed character than the section of the same in *M. superbus*. The median plane of the sphenoid is prominent, and is continued as a wedge with the apex opposite the posterior borders of the otic bullæ. The palatine borders are parallel, except where they form on each side an open angle at the junction of the descending process of the sphenoid, which is here directed forwards. Its external border is distinct from that of the palatopterygoid plate, and makes a groove with it. The maxillary bone is not produced posterior to the notch on either side of the base of the posterior production of the palatine bones. The middle line of the latter is deeply concave opposite the former, and the palate is also especially concave between the first true molars. The palate is flat between the first and second premolars. The inferior surface of the squamosal process of the zygoma is roughened for the origin of the masseter muscle. The inferior edge of the malar comes from its inner side, and is narrow and with a median groove. Its inferior edge is continued as a ridge of the maxillary as far as opposite the anterior lobe of the second true molar. The maxillary bones are more produced anteriorly than in any of the other species. The apex of the nasal bones stands above the posterior border of the canine in this species; above the anterior edge in *M. superbus*, *M. chelydra* and *M. leidyi* (fide Bettany). The posterior border of the nares is above the anterior part of the first premolar in the three species named, except *M. chelydra* where it is over the posterior edge of the canine: in *M. macrostegus* it is above the posterior edge of the longer first premolar.

The infraorbital foramen is large, and its posterior border is above the anterior root of the first true molar. The incisive foramina are large, and each one is a little longer than wide. The nareal opening contracts gradually to its inferior apex. There is a considerable maxillary foramen opposite the middle of the fourth superior premolars. The posterior nareal is not large; its anterior outline is regularly concave. Its lateral (sphenoid) borders reach to opposite the anterior faces of the postglenoid processes and bound the foramen ovale on the inner side. The latter is round, is rather small, and is opposite the middle of the postglenoid surfaces. The foramen rotundum on the other hand is large and vertically oval, and is bounded below by a transverse prominence of the base of the alisphenoid bone. It probably includes the sphenoörbital foramen, a foramen anterior to its inferior border probably communicating with the nareal chamber. The optic foramen is small, and is situated opposite the anterior two-fifths of the zygomatic fossa and a little above the line of the apex of the foramen ovale. The foramen lacerum is ovoid and not large. The posterior foramen lacerum is a transverse sigmoid, one extremity being the jugular foramen. The mastoid and postpariëtal foramina are of moderate and equal sizes. No postsquamosal or supra- or postglenoid foramina.

The animal described is too old to exhibit sutures.

The mandible possesses some distinctive characters. The angular border is not prominent posteriorly, extends forwards below, and projects below the general level of the inferior border of the ramus. Neither of these characters is observable in the only ramus of the *M. superbus* in which the lower part of this border is well preserved, but in some others of that species the superior part of the border is much as in *M. macrostegus*. The inferior edge of the ramus is straight, but there is a descending tuberosity of the symphysis which may be an individual peculiarity. The symphysis is very concave in profile, and the incisive border is produced in accordance with the prolonged muzzle. In the *M. superbus* it is sometimes convex, sometimes a little concave, but not so much so as in this jaw. The coronoid processes are small and slightly everted. The inner ridge of its anterior base is more prominent than the exterior, and encloses a fossa with it. The masseteric fossa is not noticeable. There is one large mental foramen below the third premolar. The dental foramen is large and oval, and when the mandible stands on a level surface is opposite the middle lobe of the third inferior molar tooth.

In dentition this species is distinguished by the relatively large size of the premolar teeth, of which the first, second and third are two-rooted in both jaws. Both the first and second in the upper jaw have short diastemata anterior and posterior to them, the largest being behind the canine tooth, and nearly as long as the premolar's crown. All the teeth are a good deal worn in the specimen. One can see two internal cingula inclosing fossæ on the third premolar. The true molars increase in size rapidly posteriorly and the third has a well-developed external heel. The molars have no internal cingula ; these are present in five of seven skulls of the *M. superbus* where these parts are cleaned. The most noteworthy point in the mandibular dentition is a very rudimental character of the internal vertical ridge of the crown of the first premolar. The posterior fossa of the fourth premolar is closed, and the anterior remains open, on wearing. In *M. superbus* both are closed in the specimen where visible. The anterior inner wall is represented in the second and third premolars by a cingulum. No cingula on the true molars. First premolar very robust, its section lenticular.

Measurements.	M.
Axial length from occipital condyles* to premaxillary border	.345
Axial length from occipital condyles to postglenoid process	.045
Axial length from occipital condyles to postfrontal process	.138
Axial length from occipital condyles to palatonareal border	.100

*The occipital condyles are broken off in the specimen, so I measure from the superior border of the foramen magnum, which is, in the other species, in the vertical line of the occipital condyles.

Measurements.	M.
Axial length from occipital condyles to end of last molar	.058
Diameters of orbit { vertical	.044
Diameters of orbit { transverse	.036
Depth malar bone at middle of orbit	.037
" zygomatic process to glenoid face behind	.077
" skull (right angles to profile) at glenoid face	.088
" " " " " " orbit	.088
" " " " " " P-m. i	.068
Elevation of occiput from foramen magnum	.084
Width top of muzzle at preorbital fossa	.038
" at middle supraorbital border	.109
" " postfrontal process	.137
" " malar below orbit	.166
" " middle of zygomatic arch	.243
" of occiput at superior crests	.050
" " " condyles	.101
Length superior dental series, with canine	.177
" " premolar series	.092
" " true molar series	.083
Diameters canine { anteroposterior	.013
Diameters canine { transverse	.018
Diameters P-m. i { anteroposterior	.017
Diameters P-m. i { transverse	.075
Diameters m. i { anteroposterior	.019
Diameters m. i { transverse	.0215
Diameters m. iii { anteroposterior	.038
Diameters m. iii { transverse (at middle column)	.029
Width of palate at P-m. i	.061
" " m. i	.053
" " middle of zygomatic arch	.047
Length of inferior dental series with canine	.179
" " premolar series	.088
" " true molar series	.088
" of ramus to posterior edge	.279
Depth of ramus mandibuli at condyle	.124
" " " m. iii posteriorly	.073
" " " m. i posteriorly	.048
" " " P-m. i (front)	.015
Diameters inferior P-m. i { anteroposterior	.019
Diameters inferior P-m. i { transverse	.0125
Diameters " P-m. iv { anteroposterior	.021
Diameters " P-m. iv { transverse	.013
Diameters " m. i { anteroposterior	.020
Diameters " m. i { transverse	.014

	Measurements.	M.
Diameters inferior m. iii	anteroposterior	.044
	transverse	.018

This fine species is from the John Day epoch of the Miocene. The typical specimen was found by my assistant, Charles H. Sternberg, on Bridge creek, Oregon. Much credit is due Mr. Sternberg for his unwearied exertions in the cause of science, which have been continued through many occasions of risk and discomfort.

Merycochœrus montanus, sp. nov.

This large animal is represented in my collection by a nearly entire skull with parts of both mandibular rami complete. Rami of another individual give the entire dentition of the lower jaw except the incisors. A third individual is represented by a symphysis with premolars, canines and incisors, and by various parts of the skeleton, including feet. Of the cranium mentioned, the muzzle to the preorbital fossa and the palate to the first true molar are wanting. The region of the larmier is lost, but the general resemblance of the species to the *M. macrostegus* in other respects, leads me to suspect that it is absent, and that the *M. montanus,* is rightly referred to the genus Merycochœrus. This course is indicated by the structure of the superior molar teeth, which have the character of those of this genus, rather than that found in Merychyus. That is, the posterior internal crescent sends its anterior horn to the external wall of the crown, thus cutting off the posterior horn of the anterior crescent. Dr. Leidy has shown that the reverse is the case in the *Merychyus major;* that is that the posterior horn of the anterior crescent reaches the external wall of the crown, cutting off the anterior horn of the posterior crescent. I have observed that this is also the case in the other species of Merychyus which have come under my notice.

The posterior position of the infraorbital foramen and the greatly produced palate distinguish this species from those of the John Day epoch, excepting the *M. macrostegus,* while in the *M. rusticus* and *M. proprius,* the infraorbital foramen is still further posterior. The palate of these species is unfortunately unknown.

The part of the maxillary bone posterior to the infraorbital foramen is nearly flat, and the proximal part of the malar bone is also flat. The inferior edge of the latter is narrow and is marked by a groove which terminates anteriorly in a shallow fossa. The ridge continuous with this edge terminates above the anterior lobe of the second true molar. The zygoma as far as the anterior border of the glenoid cavity is slender, and not convex, but flat in every direction, nor is it decurved as in *M. superbus.* The zygomatic foramen is relatively much smaller than in that species. Its posterior or preglenoid boundary is not at right angles to the sagittal crest as in that species, but is oblique outwards and forwards at an open angle. The obtuse median edge of the zygoma looks upwards, not outwards as it does in *M. superbus* and *M. macrostegus,* and the superior expansion is

opposite the internal extremity of the glenoid face, instead of the external as in *M. superbus*, or the middle, as in *M. macrostegus*. The border descending to the supraauricular crest is thin and vertical in direction, and the superior angle stands above the middle of the postglenoid process, not external to it, as in the two species above named. The postglenoid process is robust and has a convex posterior face. The paroccipital process is long and acuminate. An external truncate ridge on the front of its base partially embraces the meatus auditorius, and curving forwards becomes the anterior edge of the process, which is separated from the postglenoid by but a narrow interval. The tympanic bone forms a tube more distinct from the surrounding regions than in the other species here described, and has a longitudinal inferior keel, which is not visible in the *M. superbus* and *M. macrostegus*. It is separated at the meatus by but a short interval from the base of the postglenoid process. The supraauricular and mastoid crests unite and form a short acute crest, which does not continue into a prominent posttemporal, but descends into a mere angle, which continues as a fine line to the convexity of the true posttemporal crest above. The latter arises from the bifurcation of the sagittal crest, and after a strong convexity descends with its fellow to a narrow prominent convex ridge, which rises from the foramen magnum. Thus the occiput on either side of this prominent middle line is deeply excavated, and the fossa is bounded on each side and anteriorly by the low posttemporal angle, and the more prominent mastoid ridge. There is no median keel. The median ridge of the occiput is more prominent and not so flat as in *M. superbus*, but is more as in *M. macrostegus*. The sagittal crest is well developed, and has a straight superior border, which is not thickened as in *M. chelydra*. The anterior temporal ridges are represented by an angle which is nearly right. The superior squamosal suture is marked by a prominent ridge. The front is gently convex transversely, and the supraorbital border is more strongly decurved than in *M. superbus*, which are more so than in *M. macrostegus*.

The basicranial axis makes a strong angle with the basifacial as in the other species of the genus, showing that the face was presented obliquely forwards, as in the peccary. The section of the basioccipital bone between the paroccipital processes is V-shaped, owing to the presence of a strong median angle. In *M. macrostegus* this bone is similar, but in *M. superbus* it is much flatter, and there is a weak median keel. The sphenoid is in line with the occipital and has a broadly rounded-truncate inferior face. The otic bullæ are large and compressed. They extend from the middle of the base of the paroccipital process to considerably in advance of the postglenoid process, and approach very near to the glenoid surface. The interval which separates them is small, equaling one-fifth the anteroposterior diameter of the bulla. This is very different from the *M. macrostegus*, where the space between the glenoid surface and the bulla, is equal to the anteroposterior diameter of the latter near the middle. As already pointed out, this species agrees with the species just named in the

great prolongation of the palatal floor of the nareal cavities. The distance from the foramen magnum to the nareal border equals the distance from the latter to the line connecting the median external vertical crests of the last superior molars. In *M. superbus* the former measurement is two and one-half times as great as the latter.

The mandible shows the nearer relationship to the *M. macrostegus* than to the *M. superbus*, in the anterior elongation and greater relative size of the premolar teeth. It agrees with the former in having the profile of the symphysis concave, and not convex as in *M. superbus*. It is less concave in my single specimen than in that of *M. macrostegus*. The position of the posterior extremity of the symphysis is below the middle of the third inferior premolar. The coronoid process is low, and of small size. Its compressed convex apex is directed at an angle of 45° from the middle line outwards and forwards. Its anterior face soon widens out and the internal edge becomes much more prominent than the external, with which it encloses a shallow, subtriangular, subvertical fossa. The external border is continuous with the external alveolar border. The masseteric fossa is small and has no distinct inferior border, and does not descend below the level of the line of the middle molar teeth. The inferior border of the ramus is nearly straight. The inferior incisive alveolar border is much more strongly convex than in the *M. superbus*. The condyle has the posterior articular face on the inner side, as in other species.

The infraorbital foramen is large and is above the anterior part of the first true molar tooth. The meatus auditorius is small. There are two postparietal foramina on the pariëtosquamosal suture. No supraglenoid or postglenoid foramina. There are two mental foramina, one not small below the anterior part of the first true molar, the other, quite large, below the posterior part of the third premolar. The dental foramen is situated on a level with the alveolar border and well posteriorly, its anterior border being a little in front of a line dropped vertically from the apex of the coronoid process. It is thus similar in position to that of *M. macrostegus* and different from that of *M. superbus*, where it is above the line of the apices of the molars, and is posterior to the line dropped from the apex of the coronoid.

In the superior true molars, the size increases rapidly posteriorly. The third is relatively of more elongate form than the first, but the posterior external column is but little produced. The other vertical ridges are quite prominent. The external faces of the external lobes are nearly flat. Besides the relation of the adjacent horns of the internal crescents already mentioned, the posterior horn of the posterior crescent in the first and second molars is cut off from the external wall of its own crown by the anterior horn of the anterior crescent of the crown next posterior. This does not exist in worn molars of *M. superbus* and *M. macrostegus*, but is observable in little worn teeth of the former. It does not look as though the character would disappear with wear in the *M. montanus*. The only

trace of cingulum on the superior molars is on the inner base of the anterior lobe, where it is weak, and in the interspace between the internal lobes, where it is a narrow tubercle. Enamel obsoletely vertically striate. It is wanting on the external side of the internal crescent, as Leidy has shown to be the case in certain species of Merychyus. The fifth lobe of the last inferior molar is well developed and has its two crescents separated by a groove. The adjacent horns of the external crescents are of about equal length. No cingula, except a trace on front and rear of crowns, and a tubercle between the bases of the external lobes. The fourth premolar has two fossæ isolated, one anterior to and the other posterior to the principal apex, which is double, and anterior to the middle. Before wear, each of these fossæ opens inwards. The crown of the third premolar has its inner face unequally divided by a crest behind the middle. Posterior to this the space is occupied on the inner side by two shallow fossæ of which the posterior is the narrower. Anterior part of inner face of crown concave. One principal angular cusp. The second premolar has a compressed triangular crown with a long base, and a weak vertical ridge on the internal side. The first premolar is a very robust tooth with a straight posterior border directed at 95° forwards, and is vertically truncate in the specimen by friction with the canine. Section of crown lenticular, rounded in front.

Measurements.	M.
No. 1.	
Length from occipital condyle to postglenoid process...	.049
" " " " " postfrontal process...	.135
Width of occiput at posttemporal crests.	.054
" " " condyles.	.102
Elevation of occiput above foramen magnum.	.084
Length from foramen magnum to palatal border.	.060
Width between apices of otic bullæ.	.042
Length from inferior m. iii to apex of coronoid process.	.075
" of superior true molar series.	.084
Diameters m. i { anteroposterior	.026
Diameters m. i { transverse (at middle rib)	.025
Diameters m. iii { anteroposterior.	.034
Diameters m. iii { transverse (at middle rib).	.025
Length of inferior true molar series.	.085
Diameters P-m. iv { anteroposterior.	.0205
Diameters P-m. iv { transverse behind.	.015
Diameters m. i { anteroposterior	.022
Diameters m. i { transverse.	.016
Diameters m. iii { anteroposterior.	.040
Diameters m. iii { transverse..	.022
No. 2.	
Length of ramus mandibuli from incisive border to condyle (oblique).	.280

Measurements.	M.
Length of dental series (straight line)	.191
" from last molar to apex of coronoid	.0735
" of premolar series	.085
" " true molar series	.084
" " second premolar on base	.021
" " first premolar on base	.0225
Depth of ramus at coronoid	.044
" " " end of m. iii	.073
" " " middle m. i.	.056
" " " P-m. i. vertically	.034

The specimens of this species were found by Mr. J. C. Isaac in the Ticholeptus beds of Deep river, Montana, during his Expedition of 1880.

Merycochœrus rusticus Leidy.

Report U. S. Geological Survey Terrs., 1873, i, p. 199, Pl. III, figs. 1–3; VII, figs. 1–5; XX, figs. 9–81. Proceedings Academy Philadelphia, 1870, 109.

The smallest species, characterized among other things by the closure of that part of the nareal fissure which separates the premaxillary bones below. According to Leidy's figure above quoted, the depth of the middle line of the undivided premaxillary is greater than the width of the bone, a state of things not approached by any of the species of this genus described in the preceding pages. The premaxillary in the *M. proprius* is not described.

From the ? Ticholeptus beds of the Sweetwater river, Wyoming.

Merycochœrus proprius Leidy.

Proceedings Academy Philadelphia, 1858, p. 24; Extinct Mammalia Dakota and Nebraska 1869, p. 110; Pl. X.

This large species represents the extreme form of the genus in the anterior position of its dental series as compared with the braincase. The zygomatic arch and infraorbital foramen are therefore more posteriorly placed than in any other species. The premaxillary bone is more prominent than in any other, and the incisor teeth have relatively larger dimensions. The size is about that of the *M. superbus*. I have not seen any other than the typical specimen.

From the Ticholeptus beds at the head waters of the Niobrara river, Nebraska.

MERYCHYUS Leidy.

Proceedings Academy Philad'a, 1858, p. 24, (nomen nudum). Extinct Mammalia Dakota and Nebraska, 1869, 115. Report U. S. Geological Survey Terrs. i, 1873, p. 202. Cope, American Naturalist, 1884, p. 281. *Ticholeptus* Cope, Bulletin U. S. Geolog. Survey Terrs., 1878, p. 380.

Premaxillary bones coössified; otic bulla swollen; a vacuity between

the maxillary, lachrymal, and nasal bones, or larmier. Nasal bones normal. First inferior premolar caniniform.

This genus has not been defined prior to the present article, although some characters common to the species of the genus known to him, have been given by Leidy. As now defined it is identical with genus *Ticholeptus* Cope. This group was distinguished by the presence of a larmier, a character whose presence in the species of Merychyus has been hitherto unknown. It is not yet reported indeed as present in any of the original species of the latter, but I think that there can be no reasonable doubt of its presence there. A character found by Leidy in the *M. major* I find to be present in one or more of the superior molar teeth in all the species. The posterior horn of the anterior internal crescent cuts off the adjacent or anterior horn of the posterior internal crescent from contact with the inner side of the external wall of the crown. It is the anterior horn of the posterior internal crescent which reaches the external wall, in the genera Merycochœrus, Eucrotaphus and Oreoden. In Leptauchenia the arrangement is generally as in Merychyus; see under the head of that genus.

This genus is confined to the Upper Miocene beds, the Ticholeptus and Loup Fork epochs. In size the species range from medium to large, the *M. major* equaling any species of the family in dimensions. They are distinguished as follows:

I. True molar teeth not prismatic.

Infraorbital foramen above fourth premolar; malar bone shallow; squamosal with superior zygomatic angle anterior; true molars M. .042 ..... *M. pariogonus.*

II. True molar teeth more or less prismatic.

a. Infraorbital foramen above third premolar.

Larmier a slit; front narrow ..... *M. arenarum leptorhynchus.*

aa. Infraorbital foramen above fourth premolar.

β. Zygomatic arch vertical, and with posterior angle small and rounded.

Larmier triangular; front wide; true molar series M. .044; face convex ..... *M. arenarum arenarum.*

ββ. Zygomatic arch expanded horizontally; posterior angle strong, acute.

Larmier large; true molars .051 ..... *M. zygomaticus.*

βββ. Zygomatic arch unknown.

Facial plate generally concave; true molars M. .045 ..... *M. elegans.*

True (inferior) molars, M. .069 ..... *M. medius.*

True (superior) molars (m. iii inferred), M. .095 ..... *M. major.*

Of the above species, the *M. arenarum* and *M. zygomaticus* are known from entire skulls. In the first named, the foramen infraorbitale appears to be partly above the posterior edge of the third premolar, as well as above the anterior edge of the fourth.

Merychyus arenarum Cope, sp. nov. Sub-species **leptorhynchus** Cope.

This species is represented by a skull which lacks of completeness only the extremity of the muzzle and the angles of the lower jaw. Its size is about that of the *Oreodon culbertsoni* or of the *Merychyus elegans*. The confluence of the premaxillary bones shows that the place of the species is with the last-named genus, and the sigmoid flexure of the masticating line of the superior dentition is a point of resemblance to the species of the same. The position of the external infraorbital foramen is one degree further posterior than in the species of Oreodon, and agrees with the position in two other species of Merychyus (*M. arenarum* and *M. pariogonus*), which is more anterior than in the other species of the genus. The foramen is in fact quite identical in position with that seen in most of the species of Eucrotaphus, to which genus the above named species must be regarded as the nearest in the genus to which they belong.

As in other species of the genus, the malar bone is deeper and less prominent laterally than in those of Oreodon. The preorbital fossa is wider and shallower. The orbit is closed behind.

The premaxillaries are convex in every direction, least so transversly. The fissure which separates them is quite narrow, and is separated from the alveolar border by a rather narrow isthmus of uninterrupted bone. At the canine tooth the direction of the surface becomes longitudinal by an abrupt turn, and the side of the face above the second premolar is uninterruptedly gently concave. The lateral convexity which bounds the preorbital fossa below, appears above the third superior premolar, and becomes more prominent posteriorly as it passes into the flat surface of the malar bone. The anterior orbital border is prominent and thin, and does not develop a distinct tubercle, although its edge is roughened. The profile of the muzzle is a straight line descending gently from the interorbital region. Above the middle of the orbits the frontal bones are gently convex; on the line of their anterior border, there is a concavity of the median line. The superior face of the nasal bones is flat, and is peculiarly narrowed, especially posteriorly, where the large preorbital fossæ approach each other.

The anterior temporal ridges are well marked, and after a gradual approach unite into a sagittal crest, which has a gently convex rising profile. After the posterior bifiurcation of the latter, the convex posterior temporal crests do not project beyond the occipital condyles when the inferior edge of the lower jaw rests on a horizontal plane, as in so many other species of this genus and of its allies. These crests continue without interruption above the auricular meatus to the posterior base of the postglenoid process. As compared with the *Oreodon culbertsoni*, the postorbital part of the cranium is short; it is also shorter than in any other species of Merychyus. Thus the length from the posterior border of the orbit to the convexity of the

posterior temporal crest, is as long as from the former point to the anterior base of the first premolar. In the *Oreodon culbertsoni*, the same measurement is equal to the length from the same point to the anterior base of the third incisor. This shortening posterior to the orbit is seen to involve the zygomatic fossa as well as the region posterior to it. Thus the horizontal diameter of the orbit in the *M. leptorhynchus* is exactly equal to the distance between the posterior border of the same and the anterior edge of the glenoid cavity. The posterior part of the superior edge of the squamosal zygomatic process is thin and strongly convex. The apex of the convexity is above a point just anterior to the posterior border of the glenoid cavity. The posterior edge of the process is nearly vertical, and if continued would reach the middle of the base of the postglenoid process. The latter is compressed and rather elongate, and its convex edge has considerable transverse extent. The paroccipital process is long and is flat on its posterior face. The postorbital process of the frontal is elongate wedge-shaped, with its truncate apex below joining a slight elevation of the malar bone, which is much less prominent than in *Oreodon culbertsoni*. It presents an angle outwards and forwards, as the orbital border. The anterior half of the zygomatic process of the malar bone is rounded-truncate below. The glenoid surface is plane transversely, and slightly convex, rising backwards, anteroposteriorly. The anterior border of the squamosal bone is not developed into a ridge.

The frontal bone extends forwards on either side of the nasals, forming a narrow process above the lachrymal bones. It overlaps the superior edge of the maxillary, of which a narrow splint appears between it and the nasal. The nasals are rather narrow, and each has the posterior border rounded. The latter fall above the middle of the first true molar tooth when the inferior edge of the mandible is horizontal. The lachrymal bone has greater anteroposterior than vertical diameter, extending nearly to the line of the infraorbital foramen, or much in advance of its position in *Oreodon culbertsoni*, *Eucrotaphus jacksoni*, or *Merycochœrus superbus*. The malar bone has a correspondingly large anterior extension, reaching to above the posterior part of the fourth premolar. It does not extend so far in the three species just named. The zygomatic process of the squamosal is more deeply received into the malar bone than in any of the three species mentioned, reaching to below the posterior third of the orbit.

The larmier in this species is small, and its anteroposterior diameter is more than twice as long as the vertical. More than half of its inferior border is formed by the maxillary bone. As it is exhibited in the specimen, its superior border is formed by the ascending process of the maxillary bone; whether this is overlapped by the laminar process of the frontal so as to bound the foramen, when in a perfect condition, is uncertain. The posterior edge of the larmier is the lachrymal bone. The external *foramen infraorbitale* is on one side double. The supraorbital foramina form notches at the anterior edge of the supraorbital border. The frontal

foramina are well separated from each other, as in the species of Merycochœrus. The space between them is about equal to that between each one and the superciliary border. There is a large postparietal foramen near the parieto-squamosal suture. If the supraglenoid foramen be present it is not distinguishable in the specimen. The orbit is rounded subquadrate, with the inferior anterior angle a little produced.

The ascending process of the mandible is relatively elevated. The horizontal ramus narrows rapidly anteriorly, and the symphysis mandibuli is produced so as to rise at a very low angle. The alveolar portion is horizontal.

The superior incisors are small and their apices are but little expanded, the external the most so. They are directed vertically downwards. The superior canine is quite small; its crown exceeds in length that of the first premolar by but little, and is directed a little posteriorly as well as downwards. The roots of the first premolar are not as well distinguished as in many other species, and are united in their extra-alveolar part at least. The same is true of the second premolar. The apex of the cutting edge is in line with the anterior border of the crown; the rest of the edge rises obliquely backwards. In the third premolar there is a slight bevel in front of the apex, which is much better developed on the fourth. These teeth are more truncate than the corresponding ones of the species of Oreodon and Eucrotaphus, and the larger species of Merycochœrus. The external faces of P-m. i and ii are convex; that of P-m. iv is concave, but without the reverted vertical borders seen in *Oreodon culbertsoni*. The first true molar has long roots and a short crown. The last two molars have crowns of a more elongate character, with well developed anterior and middle ridges. The latter are not so prominent as those of the molars of the *Merychyus zygomaticus*.

The inferior incisors are directed upwards at an angle of about 30°. They are similar and closely packed. The inferior canine is in close contact with the third incisor, from which it differs in its larger, leaf-shaped crown. The inferior first premolar is a slender one-rooted caniniform tooth, with narrow crown and acute apex. The second premolar is one-rooted, and has a leaf-shaped crown, with acute-angled apex. The third is two-rooted, and has a wider and nearly symmetrical crown. The fourth is much larger, and its elongate crown laps inside of that of the third. Its low angular apex is median. The last inferior true molar is disproportionately larger than the others. No external cingula.

Measurements of Skull.	M.
Length from occipital condyle to premaxillary border	.161
" " " " " postglenoid process	.030
" " " " " postfrontal process	.078
" " " " " preorbital border	.130
Diameters of orbit { vertical	.0250
Diameters of orbit { transverse	.0255

Measurements of Skull.	M.
Depth of malar bone at middle of orbit	.0195
" " zygomatic process at glenoid face (greatest)	.021
Width of top of muzzle at larmier	.0175
" at middle of supraorbital border	.051
" " malar bones	.077
" " zygomatic processes of squamosal	.0795
" of occipital condyles	.031
Elevation of occiput, including condyles	.054
Width of occiput at middle	.033
Depth skull at right angles to profile, at glenoid face	.046
" " " " " " orbit	.049
" " " " " " larmier, exclusive of teeth	.044
Depth of mandible at condyle	.071
" " " m. ii (middle)	.025
" " " P-m. iii	.022
Length of superior dental series	.0885
" to superior P-m. i	.0130
" " " m. i	.0470
" of " m. iii	.0180
" " " canine, crown	.009
" to inferior P-m. i	.012
" " " m. i	.0425
" of " dental series	.087
" " " m. iii	.022

The unique and beautiful specimen on which our knowledge of this species rests, was found in a formation of the Ticholeptus Miocene near Laramie Peak, Wyoming Territory, by my assistant, J. C. Isaac.

Merychyus arenarum, sp. nov. Sub-species **arenarum.**

This species was more abundant than the *M. leptorhynchus* during the Ticholeptus epoch, if we may judge from the number of specimens which have been procured. I enumerate here the five most important, viz.: No. 1, A skull which lacks the muzzle as far as the preorbital fossa, and the palate as far as the third premolar, and which has the mandible complete as far as the coronoid processes, and which is accompanied by fore and hind feet and other limb bones. No. 2, A muzzle and right side of the face including the orbit, with the entire dentition, including that of the premaxillary bone, and that of the right mandibular ramus as far as the second true molar inclusive. No. 3, A skull with a part of the mandible, of an immature individual, in which the last superior molar is just appearing, and the last two temporary molars are in place, and which is accompanied by a few bones of the limbs. No. 4, Palatal part of skull, with nearly all the teeth, accompanied by perfect mandible with all the teeth, and a large part of the skeleton. No. 5, A skull from which the basi-

cranial region, zygomata, and left maxillary bone, have been lost. The measurements of No. 4 somewhat exceed those of the other specimens, so that it is doubtful whether it really belongs here.

The characters which distinguish this form from the *M. leptorhynchus* are not numerous. In the first place the front and muzzle are relatively wider. Secondly, the larmier is of a different form. Instead of being a horizontal slit, it is subtriangular, with the base above, and the angle below; thirdly the canine teeth are more robust in both jaws. But the position of the infraorbital foramen is slightly variable, and the width of the front in one specimen is about as in the sub-species *leptorhynchus*. The size of the canine is not invariable. I am therefore precluded from regarding the *M. leptorhynchus* as more than a sub-species.

As compared with the *M. elegans*, the strong convexity of the side of the face distinguishes it. The convexity continues from the malar region forwards above the infraorbital foramen, and nearly reaches the nareal opening. Judging from Leidy's fig. 11, Plate XI, of the Extinct Mammalian fauna of Dakota and Nebraska, the premaxillary bone of the *M. elegans* is flatter than in the *M. arenarum*. The infraorbital foramen has a more anterior position in the latter than in the former.

The size is always a little larger than in the type specimen of *M. leptorhynchus*.

Measurements.	M.
No. 1.	
Length from occipital condyle to postglenoid process...	.037
" " " " " postfrontal process....	.076
" " " " " preorbital border.....	.105
Transverse diameter of orbit.....	.030
Depth of malar bone at middle of orbit.....	.019
" " zygomatic process at glenoid face (greatest)..	.019
Width at middle of supraorbital border.....	.062
" " malar bones.....	.096
" " zygomatic process of squamosal.....	.100
" of occipital condyles.....	.034
" " occiput at middle.....	.036
Elevation of occiput including condyles.....	.054
Depth of skull at right angles to profile at glenoid face.	.041
" " " orbit (exclus. teeth).....	.051
" of mandibular ramus at m. ii.....	.030
" " " " P-m. iii.....	.022
Length of last five superior molars.....	.064
" " true molars.....	.043
Diameters P-m. iii { anteroposterior.....	.010
Diameters P-m. iii { transverse.....	.010
Diameters m. i { anteroposterior.....	.013
Diameters m. i { transverse.....	.013

Measurements.	M.
No. 1.	
Diameters m. iii { anteroposterior	.019
Diameters m. iii { transverse	.015
Length of inferior dental series (axial)	.098
" " premolar series (axial)	.038
Long diameter of crown of canine	.007
" " " P-m. i.	.0086
" " " P-m. ii	.0084
Diameters P-m. iv { anteroposterior	.012
Diameters P-m. iv { transverse	.009
Diameters m. ii { anteroposterior	.0147
Diameters m. ii { transverse	.010
Diameters m. iii { anteroposterior	.0223
Diameters m. iii { transverse	.010

The specimens all came from the Ticholeptus beds near Laramie Peak, Wyoming, and were discovered by my assistant, J. C. Isaac.

Merychyus pariogonus, sp. nov.

The generic position of this species is uncertain, and it may belong to Merycochœrus or even to Eucrotaphus, as its otic bullæ are inflated. The doubt as to its position is due to the fact that the anterior part of the skull of the typical specimen is lost as far back as the anterior border of the orbit, and the second molar tooth. I place it here provisionally because the internal crescents of the superior molars are arranged as in *M. major* and *M. arenarum, i. e.*, with the anterior crescent excluding the posterior at the point of junction of the two.

The *Merychyus pariogonus* is about the size of the *Oreodon culbertsoni.* The braincase is full, so that the internal side of the temporal fossa is strongly convex, but without very prominent ridge along the pariëto-squamosal suture. The anterior temporal ridges unite at an acute angle, but the sagittal crest is obsolete as far as a point above the posttympanic process, where it gradually rises. The posterior temporal ridge is prominent superiorly, but is not produced beyond the line of the occipital condyles. It is discontinued in the direction of the supraauricular ridge, but continues downwards as an obtuse ridge on each side towards the foramen magnum. Between this and the squamoso-occipital angle is a large open fossa which is present in the species of this genus, of Merycochœrus and of Eucrotaphus, but is wanting in *Oreodon culbertsoni.* In the obsolescence of the posterior temporal crest it agrees with the last named species, and with some of those of Merycochœrus, but differs from *Eucrotaphus jacksoni* where it is low, and from *Merychyus leptorhynchus,* where it is well developed. In the size of the lateral occipital fossæ this species exceeds any of the others of this family. Below the depression, the posterior temporal crest rises abruptly, forming a convex edge which continues downwards nearly obsolete, on the suture between the post-

tympanic and paroccipital processes. It is not distinctly continuous over the auricular meatus. The paroccipital process is elongate and acuminate, and becomes compressed so as to be anteroposterior for the greater part of its length. The auricular meatus occupies but a small part of the space between the posttympanic and postglenoid processes. It is partially enclosed by the robust rounded ledge of the squamosal bone, which separates it from the postglenoid process. This ledge is much more developed than in any other species of this family known to me. The bulla of the petrous bone is longer anteroposteriorly than transversely, and its anterior and posterior borders coincide with the anterior border of the postglenoid process, and that of the paroccipital process. The postglenoid process is robust, much as in the large species of Merycochœrus, and not compressed as in *Merychyus leptorhynchus* and *M. arenarum*. The zygomatic arch is slender. The elevation of the posterior part of the zygomatic process of the squamosal has a different form from that seen in the species last named. It is angulate, not rounded. The position of the angle is different from that in *M. zygomaticus* in being more anterior, marking a point well in front of the anterior base of the postglenoid process. The border which connects the angle with the supra-auricular crest is then not vertical as in the species just mentioned, but is oblique, and it is also somewhat concave. The malar bone is shallow and stout, with truncate edge below. The squamosal process enters it to below the posterior third of the orbit. The postfrontal process is slender, and the postorbital process of the malar is elongate, meeting the former opposite the middle of the orbit. It is thus longer than in any species of the family known to me.

The frontal foramina are separated by an interspace equal to four-fifths the distance between each and the superciliary border. The pariëto-squamosal suture ascends posteriorly in a nearly straight line to within M. .015 of the posterior zygomatic crest. The posterior squamosal suture then turns directly downwards, reaching the depressed portion of the crest where it bounds the huge mastoid fossa and foramen.

The posterior part of the mandibular ramus, shows a regularly convex angular border commencing just below the condyle. The coronoid process is quite small and the short connecting edge between it and the condyle is not excavated below the level of the latter. The articular face of the condyle is directed upwards, and on the internal third, presents a face posteriorly also. The ramus diminishes rapidly in depth anteriorly. The masseteric fossa does not descend below the level of the second true molar, and is not sharply bordered anywhere. The internal pterygoid fossa on the other hand occupies the entire inner face of the angle between the condyle and the inferior border, and anteriorly to the line of the last inferior molar tooth.

The superior true molars have short crowns, as in Eucrotaphus and Oreodon. The anterior and median vertical ridges are very prominent, and the posterior vertical border of the posterior column projects to a slight

extent posteriorly. Enamel smooth. The last inferior molar is not so disproportionately larger than the second as in *M. leptorhynchus*, *arenarum* and *elegans;* and with the second, has little of a prismatic character. No cingula.

Measurements.	M.
Length from occipital condyle to postglenoid process...	.047
" " " " " postfrontal process...	.101
Vertical diameter of orbit.....	.036
Depth of malar bone at middle of orbit.....	.012
" " zygomatic process at posterior angle.....	.024
Width at middle of supraorbital border.....	.060
" " malar bones.....	.090
" of occipital condyles.....	.032
" " occiput at lateral crests.....	.036
" " " " condyles.....	.061
Elevation of occiput with condyles.....	.054
Depth of skull at glenoid surface.....	.058
" " " " orbit, exclus. malar.....	.054
" " mandible at condyle.....	.075
" " " " coronoid.....	.083
" " " " posterior edge of m. iii.....	.042
Depth mandible at middle of m. ii.....	.028
Diameters superior m. ii { anteroposterior.....	.016
{ transverse.....	.016
Diameters superior m. iii { anteroposterior.....	.020
{ transverse.....	.0155
Diameters inferior m. ii { anteroposterior.....	.015
{ transverse.....	.012
Diameters inferior m. iii { anteroposterior.....	.0225
{ transverse.....	.0115

A second specimen of this species consists of the occipital, pariëtal, and part of the frontal regions, with the right maxillary bone, and fragments of the left maxillary, of the mandible, etc. The latter demonstrates the position of the infraorbital foramen to be above the anterior border of the fourth superior premolar. The middle line of the occiput presents a keel on its superior half. The basioccipital bone between the paroccipital process is expanded laterally, and is without median angle or groove. Between the bullæ it is compressed, and its middle line forms a narrow truncation. Opposite the posterior third of the bulla, this surface ascends at an angle, and gradually widening, spreads into the general flattened convex inferior face of the sphenoid. The anterior part of the sagittal crest is a little better developed than in the typical specimen. The worn teeth indicate an old individual. The canine is large, and the first premolar has its roots well distinguished. The facial plate of the maxillary concave above second premolar. No appreciable diastema.

Measurements.	M.
Length of molar series	.081
" " premolars on bases	.041
Width of canine posteriorly	.010
Diameters P-m. iv anteroposterior	.010
Diameters P-m. iv transverse	.012

Of this species I have but two specimens, which were obtained from the Ticholeptus beds of Deep river, Montana, by my assistant, J. C. Isaac.

Merychyus elegans Leidy.

Proceedings Academy Philada., 1858, p. 24. Extinct Mammalia Dakota and Nebraska, 1869, p. 118, Pl. XI, figs. 1–11.

Niobrara river, Nebraska.

Merychyus zygomaticus Cope.

Ticholeptus zygomaticus Cope, American Naturalist, Feb. 1878. Bulletin U. S. Geolog. Survey Territories, 1878, p. 380.

This species is peculiar in having the posterior expansion of its zygomatic arch horizontal instead of vertical. It has a thickened external edge which continues into a strong posterior angle which projects behind the posterior margin of the postglenoid process. The auricular meatus is directed posteriorly in a way quite peculiar, resembling somewhat the position seen in some of the hogs. The malar bone is very prominent. The infraorbital foramen is above the contact of the third and fourth superior premolars. The larmier is large and its maxillary border descends posteriorly.

In size this species is between the *M. elegans* and the *M. medius*. If my identification of New Mexican specimens is correct, this species differs from the *M. medius* in the much less production of the premaxillary region, besides the smaller size.

Ticholeptus beds of Deep river, Montana ; J. C. Isaac.

Merychyus medius Leidy.

Proceedings Academy Philad'a, 1858, p. 25. Extinct Mammalia, Dakota and Nebraska, 1869, p. 119, Pl. XI, figs. 12–14. Cope U. S. Expl. Surv. W. of 100th Mer., G. M. Wheeler, iv, pt. ii, p. 324.

Niobrara river, Nebraska, Hayden ; Santa Fé, New Mexico, Cope.

Merychyus major Leidy.

Proceedings Academy Philada., 1858, p. 26. Extinct Mammalia, Dakota and Nebraska, 1869, p. 121, Pl. X, figs. 15–16.

This species, known hitherto from Leidy's descriptions of four of the superior molars, is the largest of the genus, and perhaps of the family. More information regarding it is much to be desired.

Headwaters of the Niobrara river ; from Loup Fork beds, according to Hayden.

LEPTAUCHENIA Leidy.

Extinct Mammalia of Dakota and Nebraska, 1869, 122. Proceedings Academy Philad'a, 1856, 88, (nomen nudum). loc. cit. 1656, 163 (nomen nudum).

As already remarked by Leidy, this genus is characterized by the presence of enormous vacuities of the superior surface of the muzzle. The genus might be described as lacking the usual superior osseous wall of the nasal cavities and maxillary sinuses. The generic diagnosis is as follows:

Otic bullæ inflated. Four premaxillary teeth. Nasal bones excessively contracted, leaving a wide interspace between them and the maxillaries. Symphysis mandibuli coössified.

This genus has but a short range in time, not having been yet found out of the Ticholeptus beds. It shows in its deficient ossification, and smaller size, that this line of the family was approaching its extinction, its decadence having already commenced in the genus Merychyus. The genera which follow in systematic order, Cyclopidius and Pithecestes, exhibit the last steps in the downward course.

I. Infraorbital foramen above P-m. iii.

"Three inferior incisors; nasal sinuses to middle of orbit; true molars .043; skull .135." (Leidy).....*L. major.*

"Nasal sinuses not extending so far posteriorly as in *L. major;* true molars .032; skull, .101." (Leidy).....*L. decora.*

"Nasal sinuses reaching to front of orbit; true molars .020; skull .085." (Leidy).....*L. nitida.*

Leptauchenia major Leidy.

Proceedings Academy Philad'a, 1856, p. 163; 1857, 89. Extinct Mammalia, Dakota and Nebraska, 1869, p. 124, Pl. XII, figs. 1–5.

Tributaries of White river, Nebraska.

Leptauchenia decora Leidy.

Proceedings Academy Philadelphia, 1858, p. 88; 1857, p. 89. Extinct Mammalia of Dakota and Nebraska, 1869, p. 127, Pl. XII, figs. 6–20.

Tributaries of White river, Nebraska.

Leptauchenia nitida Leidy.

Extinct Mammalia of Dakota and Nebraska, 1869, p. 129; Pl. XII, figs. 21–22.

White Earth creek, Dakota, tributary of the White river.

CYCLOPIDIUS Cope.

Proceedings American Philosophical Society, 1877, p. 221. *Brachymeryx* Cope, Ibidem, p. 220.

Dental formula: I. $\frac{0}{2}$: C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$. Premaxillary bones much reduced; mandibular rami coössified. Otic bulla inflated. Prelachrymal vacuities present, and confluent with enormous nasal vacuities, which are due to the excessive reduction of the nasal bones. Orbit closed behind.

This genus is Leptauchenia without superior incisor teeth, and with but two on each side below. I originally asserted the presence of superior incisor teeth, and it is true that there is in early life a minute tooth in each premaxillary bone, as indicated by the alveoli in a specimen which contains the full deciduous molar dentition. I have not seen the teeth themselves, and it is evident that they are early shed. In an adult specimen of *C. simus* it seems that the alveolar portion of the premaxillary bone has been absorbed.

The meatus auditorius externus occupies a more elevated position in this genus than in any other of the family. It is also directed somewhat posteriorly. There are postpariëtal foramina.

The cerebral hemispheres are not large, and scarcely rise above the plane of the summit of the large cerebellum. Convolutions three on each side, weakly defined.

The concavity of the superior border of the premaxillary bones, together with their upward production, leads me to suspect that the external nares were superior in position. This is the indication of an aquatic habit of life, such as is led by the hippopotamus. Like that animal, the nostrils in Cyclopidius were probably valvular to prevent the ingress of the water. The animals probably passed much of their time in the water, and the nostrils could be brought to the surface for the purpose of respiration, while the remainder of the head and body remained concealed. The prominent rim of the auditory meatus suggests a similar valvular closure of the organ of hearing, and is also a provision for its easy approximation to the surface of the water when necessary.

The milk dentition is like that of Artiodactyla in general. That is, in the superior series the third molar is more elongate and complex than its permanent successor, and the fourth is like the first permanent true molar in constitution. In the inferior series the anterior three teeth resemble the permanent premolars, while the fourth is trilobate.

In the loss of the incisor teeth and the subprismatic molars, we observe in Cyclopidius the same evidences of specialization already known in other types of Ungulates.

I know of but two species of Cyclopidius.

Cyclopidius simus Cope.

Proceedings American Philosophical Society, 1877, p. 221. *Brachymeryx feliceps* Cope, Ibidem, p. 220 (immature).

The specimens of this species in my possession embrace a complete skull with one zygoma and half of the brain-case wanting; a left maxillary bone with all the teeth; and three mandibular rami with dentition, all of adults. Of immature individuals, I have two muzzles with dentition of both sides, and six mandibular rami; in all, parts of thirteen individuals. The following description of the skull is taken from the specimen first named, which is the type of the species.

The cranium is wide and depressed, and the muzzle is short. The pro-

file descends at the orbits into the nasal vacuities, which cause a deep excavation of the facial plate of the maxillary region. The small nasal bones form a promontory below the level of the orbits, whose superior borders are convex. The maxillary bones rise at the end of the muzzle, forming, probably, with the confluent premaxillaries, a subquadrate projection. The superior side of this process is concave on its interior aspect forming a curved suture of an expanded nasal bone. Its anterior edge is also concave on their inner side, as though adapted to a forward-looking nareal opening. This anterior border is produced downwards into a free conical process which bounds the canine alveolus in front. This I suppose is all that there is of the alveolar portion of the premaxillary bone. The corresponding part of the other side is lost. There is a well-marked preorbital fossa. Its supero-interior border bounds the huge nasal vacuity on each side. The nasal bones form a narrow promontory, with convex superior face, which extends a little beyond a line connecting the middles of the preorbital fossæ. The vacuities excavate the frontal bones as far back as a line connecting the middles of the supraorbital borders. The frontal bone is thus of a Λ-shape. The anterior temporal ridges are well defined, but do not reach the free edge of the frontal bone. Their union into the sagittal crest is gradual. The brain-case is moderately elongate, the postorbital process of the malar bone marking the middle of the total length. In profile the posterior part of the skull is nearly straight. The sagittal crest is gently convex, and is not so deeply bifurcated posteriorly as in most other forms. The posterior temporal crests are expanded laterally, and continue well developed to above the meatus auditorius, into the superior edge of the zygoma. They are not continued downwards on the occiput, as in most of the other genera of the family, but resemble the species of Merychyus more than any others in this respect. The temporal fossa has a wide floor, due to the lateral extension of the meatus auditorius, and the glenoid portion of the squamosal. The superior edge of the zygomatic process of the squamosal is little elevated, and is regularly convex. The process is not produced as far anteriorly as the posterior border of the orbit. The malar bone is remarkable for its depth, exceeding in this respect any species of the family yet known. Its external face slopes obliquely outwards below, but not very much, and is slightly and uniformly convex. Its inferior edge is thickened and descends anteriorly, and then thins and rises continuously to the zygomatic process of the squamosal.

The occipital aspect of the skull is wide and low. Its superior region is slightly convex and roughened on each side of the median line. From and below this valley, the middle line presents a sharp carina, which disappears in a narrow convexity above the foramen magnum. Between this convexity and the meatus auditorius, the surface is concave. The occipital condyle is small, and the exterior half is more extensive than the posterior half. The paroccipital process is large. Its base diverges from the occipital condyle, and is adherent by its anterior face to the otic bulla,

without intervening ridge. The posttympanic mass is broken away. It is inferior in position to the auricular meatus. The latter, being directed posteriorly, is considerably produced behind the postglenoid process, leaving a wide postglenoid fossa. The postglenoid process is rather small, and its posterior face is entirely covered by the tympanic bone, while its interior edge is in close contact with the otic bulla. The bulla is of enormous size, and is a slightly compressed oval placed anteroposteriorly. It fills the entire space between the postglenoid process and the basicranial axis, and reaches anteriorly almost to the line of the anterior border of the glenoid region. The pterygoid process adheres to its internal wall for half its length, and it sends forwards on the external side of the pterygoid, a narrow acuminate apex. The internal extremity of the glenoid cavity is concave, and the surface descends, forming a robust peduncle, as large as the postglenoid process, to which the anterior part of the otic bulla is attached. This is a character I have not seen in any other species of the family. A wide surface, continuous with that of the glenoid face, extends on the external side of the pterygoid ala of the sphenoid, to the angle where it unites with the pyramidal process of the palatine. It there terminates abruptly, but the external angle marks the end of a ridge, which extends upwards and forwards to the postorbital process of the frontal. Anterior to this line the cranial wall is concave; posterior to it, convex. The processi pyramidales are divergent, and have thickened and rounded inferior edges. The maxillary bones are produced a little beyond their bases, leaving a notch between. The palatal surface is uniformly moderately concave.

The incisive foramina are large; the septa are wanting in my specimens, perhaps accidentally. The infraorbital foramen is above the middle of the fourth premolar tooth. The frontal foramina are further apart than in any other species of the family, being equidistant between the median line and the supraorbital border. There is an internal orbital foramen below the postorbital process, as in other species of the family. There are three postpariëtal foramina, two of which are on the squamosal suture. Below the anterior of these two is a large postsquamosal foramen. No supra or postglenoid foramina. The meatus auditorius externus looks equally externally and posteriorly. It is large and of oval outline, the long diameter being parallel to the superior border, which is the usual suprameatal crest. Its tympanic or anterior border is very prominent, while the posterior border is a little less so. A posttympanic tuberosity marks the middle of the inferior edge. Posterior to the meatus is the rather large mastoid foramen, which is above the internal base of the paroccipital process. The basicranial bones being lost, the characters of the basal foramina are not determinable. The posterior nares are deeper than wide. The palatonareal border is a Gothic arch, of which the apex is opposite the posterior border of the last molar tooth. I perceive no palatal foramina.

The median and posterior nasal sutures remain. The latter is a V with

the apex opposite to the frontal foramina. Lambdoidal suture confluent. The malosquamosal suture marks the posterior edge of the posterior orbital rim at the middle of the orbit. The pariëto-squamosal suture has an inferior position in front. Opposite the front of the postglenoid process it converges inwards in line for the occipital bifurcation, and is continued as the pariëtoöccipital suture, nearly to that point. The squamosal border, however, extends in a Z-form to the posterior temporal crest half-way between the bifurcation and the meatus auditorius. It embraces an area of the posterior face of the skull, and the posterior half of the rim of the auricular meatus.

The typical specimen presents only the alveoli of the canine and first premolar teeth; otherwise the dentition is perfect. The crowns of the second and third premolars are obliquely quadrate in horizontal section, both a little wider posteriorly than anteriorly. This is due to the presence of a half crescent of the internal side, whose posterior horn is attached to the external wall, while the anterior is free. The external faces of these premolars is slightly convex; of the fourth premolar is slightly concave. The first true molar is decidedly smaller than the second, and the second is smaller than the third. The external sides of the external columns are flat in the first true molar, but become more concave on the third. The anterior edges of the columns project; forming ridges; or in section, projecting angles. No intermediate ridges, nor cingula. The third superior true molar has a prismatic crown, no roots being visible in either of the adult specimens, of which the typical one is rather old, as indicated by the wear of the teeth. In the latter specimen the roots of the second true molar are apparent, although the crown is elevated. The first true molar is not prismatic, although the crown is not low. The specimen represented by the left maxillary bone contains the teeth which are wanting from the typical one. The section of the crown of the canine is a semicircle, the truncate face being posterior internal. It is not a large tooth, and is separated from the first premolar by a diastema equal to its diameter. The first premolar is one-rooted, the root with a groove on the internal side. The section of the base of the crown is a triangle, the faces being anterior, external, and posteroïnternal. Its inner face is concave above the base.

None of the separate mandibular rami are complete, all lacking the angle and condyle. The former is full and round, judging from a fragment in my possession. The ramus diminishes regularly in depth forwards. The symphyseal region is short, and its anterior face is very steep, except at the alveolar region, where it is everted forwards. No trace of suture. The internal pterygoid fossa is large and strongly marked, so that the inferior edge of the ramus is inverted, so that the surface is convex externally. The last molar is placed somewhat obliquely. The first and second premolars are directed outwards and forwards, and the incisors directed forwards.

There are two incisors on each side of the symphyseal line. They are very small and subcylindrical, and are closely packed between the canines.

The canines are much larger, with cylindric root and flat, incisor-like crown. The first premolar is still larger, and is of about the same form as the canine, from which it is only separated by a slight divergence of the crowns. There are no diastemata. The second premolar has a compressed triangular crown, with a median ridge on the internal side. Its long diameter is diagonal, running outwards posteriorly. The long axis of the third premolar is similar, while the other teeth are more nearly in line. In the third premolar the fossa interior to the median internal heel is much deeper than that posterior to it. The corresponding fossa is still larger in the fourth premolar, while the crown has a heel in the form of a transverse curved crest, separated from the median heel on the inner side by a fissure. The true molars increase rapidly in size posteriorly, but not so abruptly as in the *Pithecistes brevifacies*. The internal crescents are very flat, and the posterior edges of their columns project moderately. The external crescents are very convex. The prismatic character of the teeth increases much posteriorly, so that the roots of the third tooth are short, and the crown long. The enamel is minutely rugose.

The third superior temporary molar has two pairs of crescents. The anterior pair are, however, not so well developed as the posterior pair and the two valleys are soon obliterated by wear. The crescents are equal in the fourth temporary molar. The fourth permanent premolar is protruded at least as soon as the third true molar, sooner than the posterior column of the latter. In this it differs from the *Oreodon culbertsoni*, where the last true molar is protruded first, and is a cotemporary of both the third and fourth deciduous molars ;* and the *O. gracilis*, where the last true molar is a cotemporary of the third deciduous.

In the inferior temporary dentition, the lobes of the last molar are subequal, the posterior one being a little the larger. The protrusion of the last true molar is also probably delayed until the shedding of the deciduous series, as in the superior series ; but my specimens are either very young or fully adult, and therefore I cannot demonstrate this point as fully as in the case of the superior series.

Measurements of Skull.

	M.
Length from condyle to front of canine inclusive	.117
" " " " otic bulla (axial)	.010
" " " " palatonareal notch,	.0575
" " " " anterior line of glenoid cavity.	.038
Depth of occiput, including condyle	.041
" at middle of orbit, exclusive of teeth	.037
" " infraorbital foramen " "	.016
" " premaxillary border " "	.023
Width at " " above	.022
" between orbits	.038

*Leidy. Ancient Fauna of Nebraska, 1853, p. 51, Pl. IV, figs. 1, 2.

Measurements of Skull.	M.
Width at malars below orbits	.086
" " zygomata at middle	.092
" " auricular meatus	.070
" of occipital condyles	.0275
" at middle of last molars inclusive	.049
" " " second premolars inclusive	.030
Diameters otic bulla { anteroposterior	.023
Diameters otic bulla { transverse	.018
Diameters otic bulla { vertical	.019
Diameters of nasal bones { length of fragment of	.024
Diameters of nasal bones { width at base	.0125
Length of dental series	.062
" " premolar series	.025
" " true molar	.033
Diameters P-m. iii { anteroposterior	.007
Diameters P-m. iii { transverse	.0065
Diameters m. i { anteroposterior	.0085
Diameters m. i { transverse	.0085
Diameters m. iii. { antereposterior	.0146
Diameters m. iii. { transverse (greatest)	.011
Depth of mandibular ramus at m. iii	.031
" " " " P-m. iv	.019
Length of symphysis	.0245
" " premolar series	.022
" " true molar	.035
" " of total dental series	.063
Diameters P-m. iv { anteroposterior	.0085
Diameters P-m. iv { transverse	.006
Diameters m. i { anteroposterior	.009
Diameters m. i { transverse	.0068
Diameters m. iii { anteroposterior	.016
Diameters m. iii { transverse	.0062

The second specimen with permanent dentition is of smaller size than the type, and the canine teeth are small. It may have been a female. The dental series, including the canine, measures M. 0.59; the premolar series, 0.23; the true molars, 0.31.

The number of specimens of this animal found in the restricted area of the Ticholeptus bed of Deep river, Montana, shows the former abundance of the species. It was probably gregarious, in the manner of the other Oreodontidæ. We can depict it as seeking the swamps of the shore for its vegetable food, and spending much of its time in the water when not feeding. It was doubtless a good swimmer, and the characters of its feet will be sought for with interest for light on this point. The use of the huge superior nasal vacuity of the skull of this genus and Leptauchenia can

only be guessed. Perhaps it supported an inflatable bladder like that of the crested seal, or a swollen muzzle like that of the saiga antelope.

Cyclopidius emydinus, sp. nov.

This species is represented in my collection by a nearly perfect cranium. It indicates an animal of about the same size as the *C. simus*. The differences between the two species may be enumerated in advance of the detailed description. Firstly, the external vertical ridges or crests of the true molars are directed obliquely forwards so as to overlap the external wall of the anterior crescent much more extensively than in *C. simus*. (2) The crowns of the true molars have a relatively greater transverse diameter. (3) There is a peculiar process at the external base of the otic bulla, between the paroccipital and postglenoid processes, which may be called the subtympanic process. (4) There is no median occipital keel. (5) The maxillary bone is prolonged posterior to the last superior molar, which it is not in *C. simus*. (6) The oblique orbitosphenoid ridge is wanting. (7) The otic bullæ are shorter and wider in their form. This character will require confirmation by examination of many individuals.

The skull is singularly depressed and expanded laterally, so as to present an outline not unlike that of some river turtles. The orbits are in the anterior half, and look forwards and upwards, as well as outwards. The muzzle is short, so that its lateral borders approximate rapidly to a narrow truncate extremity. The maxillary borders do not contract quite so abruptly, and are visible outside of the canthus rostralis, when the skull is viewed from above. The brain-case is depressed, and is expanded posteriorly, and narrowed at the anterior line of the zygomatic foramina. The posterior temporal ridges are much expanded, forming a wide rim round the brain-case posteriorly, which is continued into the squamosal processes of the zygoma on each side. The anterior temporal ridges approach each other very gradually on the middle line, and only reach the union into a sagittal crest a centimeter posterior to the frontopariëtal suture. The edge of the crest is truncate, and it is not bifurcate posteriorly, as in most Oreodontidæ.

The occiput is broad and low, and differs in character from that of most other members of the family. Its posterior face is flat, only interrupted by a fossa on each side, just within the posterior edge of the meatus auditorius externus. This edge is continued downwards into the external border of a distinct mastoid process, which is also the external border of the occiput, deflected a little forwards. The paroccipital process is flat at the base, and is applied to the external half of the otic bulla. Its free extremity is subround. The mastoid process forms a prominent ala of its external side, having a transverse width equal to that of the base of the paroccipital. Its inferior edge is truncate obliquely outwards and downwards to a subacute angle. The occipital condyles are relatively small.

The external meatus of the ear looks outwards and backwards at an angle of 45° to the middle line. The prominent edge of the mastoid pro-

cess is directly below its anterior border. Thus the tympanic bone is directed obliquely downwards and forwards. Posteriorly it is separated by a groove from the mastoid process. Anteriorly it is separated by a fossa from an osseous mass which occupies the space between it and the postglenoid process. Before the skull was reconstructed from its fragments, this mass was observed to be entirely distinct from the postglenoid process, which it equals in height. Continuous with it, there descends another osseous body to near the line of the extremity of the mastoid process, with a truncate inferior edge, which is separated from the otic bulla by an open groove. The stylohyal ligament is probably inserted into a fossa at the anterior extremity of this groove. The postglenoid process is low and more extended transversely. The anteroposterior diameter is small. The glenoid surface is much extended transversely and terminates externally in a slight thickening. The zygomatic process of the squamosal bone is at first expanded horizontally and has a low convexity of the thin superior edge. Its vertically compressed portion is entirely supported by the malar, and does not extend so far forwards as the anterior edge of the zygomatic foramen. The malar bone is remarkable for the depth of its suborbital portion, which fully equals the diameter of the orbit. Its inferior edge presents a thickened angle downwards below the anterior part of the last superior molar. Its superoanterior angle terminates in a prominent rib of the side of the face, which extends along the inferior edge of the facial vacuity. Beneath the anterior part of the latter the face is concave. Above this concavity the ascending plate of the maxillary is convex in the vertical section, turning inwards at the apex to unite with the lateral part of the extremity of the nasal bone. The preorbital fossa is small and looks forwards and upwards.

The otic bullæ are larger than in any other Oreodontid. They are of a short oval form, somewhat truncate anteriorly and posteriorly. Thus they differ from those of *C. simus*, where they are elongate-oval. They only reach as far anteriorly as the middle of the internal extremity of the glenoid surface; while in *C. simus* they reach the line of the posterior outline of the zygomatic foramen. They terminate near the inferior internal point, in a little acute osseous apex, which is smaller than in *C. simus*. The bullæ approach so closely together that the bassioccipital is much narrowed, and the sides of its inferior surface are excavated so as to reduce the middle line to a narrow acute keel. The lateral excavations follow the posterior internal base of the bullæ, leaving a median table, which is itself excavated by a shallow fossa, which extends from the median keel to the foramen magnum. The median keel disappears anteriorly. The sphenoid is protuberant downwards as a narrow convex rib, which rises and disappears in the presphenoid. The descending sphenoid ala forms the posterior boundary of the posterior nareal trough, and makes a strong angle with the pyramidal process of the palatine, which is turned outwards. The pterygoid squama terminates in an apex which points downwards and posteriorly towards the apex of the otic bulla. The palatonareal border is

V-shaped, and is in line with the posterior edge of the maxillary bone. The latter projects beyond the last molar tooth as far as the anteroposterior diameter of the latter. It has no projection in the *C. simus*. There is no notch between the maxillary bone and the processes pyramidalis of the palatine. The palate is of nearly equal width from the last molar to the third premolar; its roof is gently concave posteriorly; nearly flat anteriorly.

The premaxillary bone is a narrow strip which rises nearly vertically from its short alveolar border, and is curved outwards above in agreement with the expansion of the anterior edge of the maxillary, to which it is united by simple suture. The nasal bones are of remarkable form. Together they enter the anterior part of the frontals in a V-shape, and extend forwards in a narrow shaft. Opposite the anterior borders of the orbits the shaft begins to widen gradually, and the surface to flatten, until they reach the posterior angle of the ascending part of the maxillary. Each one then expands outwards, terminating in a semi-disc which fits the concavity of the superior edge of the maxillary above mentioned. The entire shape of the nasal bones is that of a spade with a triangular apex to the handle, and the short blade at the opposite (anterior) extremity. The frontal bone is V-shaped, the angle posteriorly directed, and engaged between the parietal bones, and each branch terminating above each orbit. Narrow prolongations extend anterior and posterior to the orbit, joining the lachrymal and malar bones respectively. Its median suture is, like that of the nasal bones, well defined. The alisphenoid and parietal have extensive connection. The parietosquamosal suture is horizontal in front; it then gradually rises. It is not associated with a ridge as in some other species. The occipital forms the posterior five millimeters of the sagittal crest.

The nasal opening is subtriangular, with the base above, and is directed anteriorly. The facial vacuities are enormous, and excavate the frontals to a point which make the anterior third of the orbit's diameter. They are only separated on the median line by the very narrow isthmus of the nasal bones. The infraorbital foramen is above the anterior part of the fourth surperior true molar. The frontal foramina are small, and are not symmetrical. That of the left side is half-way between the median suture and the superciliary border; the other is nearer the superciliary border. No supraglenoid foramen. Postsquamosal present; that part of the cranial walls is injured. The anteroposterior diameter of the orbit exceeds the vertical. The auricular meatus is the largest known in the family, and it has a prominent border and regularly oval outline. Its long diameter rises posteriorly from the horizontal. It is more laterally and less posteriorly directed than on the typical and only skull of *C. simus*. The foramen magnum has an openly angulate superior border. Jugular, condyloid, and carotid foramina not obvious, owing to the close contact of the otic bulla with surrounding bones. *Foramen ovale* larger than the *F. lacerum anterius*, and external to it in position. *F. rotundum* still larger, inferior in position, bounded on the external side by a

tuberous projection of the angle from the anterior edge of the glenoid surface. There is a deep fossa at the internal base of the postglenoid process, which possibly enters a foramen. No postglenoid foramen.

Although the skull of the *Cyclopidius emydinus* is more robust than that of *C. simus;* the length of the tooth-line is the same. The incisive edge of the premaxillary bone displays one empty alveolus, from which the single incisor was easily shed. The canine is not large, and the base of the crown has a regularly convex anteroexternal face; apex lost. The diastema posterior to it is equal to its diameter. The crowns of the premolars are worn; they are of about the size and proportions of the *C. simus.* The true molars differ, as I have already pointed out, in their greater transverse diameter, and the greater anterior prolongation of the anterior horns of the posterior external crescents. The deep notch which is enclosed between this fold and the wall of the crescent in front of it is filled with cementum. As to the form of the true molars, the transverse diameter of the first considerably exceeds its anteroposterior diameter; in the *C. simus* the former diameter is equal to the latter. In *C. emydinus* the last true molar is as wide as its length without the heel; in the *C. simus,* the transverse diameter is much less. In *C. simus* the heel is more prominent, and is recurved into a vertical ridge, which is wanting in the *C. emydinus.* In *C. emydinus* this tooth shows but little of the prismatic character, as the roots are of usual length.

The lower jaw of this species is not yet known.

Measurements.

	M.
Length of skull along base	.129
Length from condyles to posterior edge of zygomatic foramen	.042
Length from condyles to palatonareal foramen	.063
" " " " line of last true molar	.071
" " occipital crests to line of orbits	.074
" " " " " facial vacuities	.084
" " " " " ascending process of maxillary bones	.115
Length from occipital crest to free end of nasal bones	.126
Elevation occiput, including condyles	.045
" of front at middle of orbit, without molars	.035
" " maxillary bone at P-m. iii	.015
" " " " " P-m. i	.025
Width of skull at occipital condyles	.0675
" " " " superior edge of meatus auditorius	.057
" " " " middle of zygomatic foramina	.092
" " brain-case at middle of zygomatic foramina	.029
" " skull at orbits	.083
" " ,, between orbits	.047
" " muzzle at superior edge of nares	.0215

Measurements.		M.
Diameter external nares	vertical	.014
	transverse above	.017
Diameter of a facial vacuity	anteroposterior	.030
	tranverse	.013
Diameter of orbit	anteroposterior	.023
	vertical	.019
Diameter of zygomatic foramen	anteroposterior	.053
	transverse	.026
Diameter of foramen magnum	vertical	.0095
	transverse	.013
Diameter of meatus auditorius	vertical	.009
	anteroposterior	.011
Diameter of otic bulla	vertical	.025
	anteroposterior	.025
	transverse	.022
Width between canine teeth		.008
" " last true molars		.0285
Length of dental series		.065
" true molar series		.0343
" premolar		.0254
Diameters P-m. ii	anteroposterior	.0056
	transverse	.0050
Diameters P-m. iv	anteroposterior	.0070
	transverse	.0080
Diameters m. i	anteroposterior	.0075
	transverse	.0110
Diameters m. iii	anteroposterior	.017
	transverse (with external rib)	.012

The only specimen of this remarkable species known to me was found in the valley of Deep river, Montana, by my assistant, Mr. J. C. Isaac. The wear of the true molars shows that the animal was of full age, though not old.

PITHECISTES Cope.

Proceedings American Philosophical Society, 1877, p. 219.

This genus represents the final term in the decadence of the once powerful and numerous family of the Oreodontidæ. It is unfortunately established on a mandibular ramus only, and although some maxillary bones are referred to it with much probability, they are not preserved in such a way as to demonstrate the presence of the large nasal sinuses characteristic of Leptauchenia. I, however, suspect that they occur. The genus further resembles Leptauchenia in the coössification of the mandibular rami, and the reduction in number of the incisor teeth. In *P. brevifacies* there is but one inferior incisor tooth on each side. As reduction in the superior incisors usually precedes reduction in

those of the lower jaw, I suspect that the former were absolutely wanting in this genus. If so, we have in the Oreodont line the same process of reduction above, as has taken place in other lines of Artiodactyla at the latest or modern stage of their history.

In Pithecistes the inferior canine is caniniform, and masticated in contact with the superior canine, owing to the great abbreviation of the symphyseal region.

The diagnosis of the genus is as follows :

Inferior premolars three ; incisors one. Canine caniniform, masticating with the superior canine. No diastema. Symphysis coössified.

Two species are referred to this genus without conclusive evidence as to the number of their premolars. It is probable that they have but three, since their superior fourth premolars are of reduced size and incomplete type of form.

Pithecistes brevifacies Cope.

Proceedings American Philosophical Society, 1877, p. 219.

Ticholeptus beds of Deep river, Montana. Discovered by J. C. Isaac.

Pithecistes decedens Cope, sp. nov.

Established on a right maxillary bone, which contains the fourth premolar, the first and second true molars, and part of the alveolus of the third true molar. The last named tooth was not probably entirely protruded. This, with the moderate wear of the fourth premolar, indicates that the animal was fully grown, though young.

The species differs from all the members of the family whose dentition is known to me in the small size and simplicity of structure of the fourth premolar. The internal crescent of this tooth bounds only the posterior three-fourths of the external wall, and therefore leaves the anterior edge of the latter free. It is, moreover, not very convex, and its edge is not so elevated as is that of the external wall. The latter is flat on the external side, and its anterior marginal angle corresponds with the point of junction of the anterior extremity of the internal crescent. The true molars have the anterior horns of their crescents prominent, being sections of well-developed vertical columns. In this they differ from those of the *P. heterodon*, where these ridges are very weak.

The malar process of the maxillary bone is robust and prominent, and begins to expand opposite the first true molar. It presents a tuberosity downwards. The infraorbital foramen issues above the front part of the fourth premolar.

Measurements.		M.
Diameters P m. iv	anteroposterior	.006
	transverse	.005
Diameter m. i	anteroposterior	.0087
	transverse	.0077
Diameters m. ii	anteroposterior.	.0115
	transverse	.008

Ticholeptus beds, Deep river, Montana. J. C. Isaac.

Pithecistes heterodon Cope.

Cyclopidius heterodon Cope, Proceeds. American Philos. Society, 1877, p. 22.

In this species the fourth premolar has the same form as in *P. decedens*, but the first true molar differs much in the more prismatic shape, and the absence of the external vertical ribs. It is quite possible that it does not belong to this genus.

Ticholeptus beds of Deep river, Montana. J. C. Isaac.

AGRIOCHŒRUS Leidy.

Proceedings Academy, Philadelphia, 1850, p. 121. Extinct Mammals Dakota and Nebraska, 1869, p. 131 (as family *Agriochœridæ*).

Orbit not closed behind. Fourth superior premolar with two external Vs. Fourth inferior premolar like true molars. Otic bulla inflated. Premaxillary bones distinct; no vacuities in the facial bones.

This genus commences cotemporaneously with the genus Oreodon, and persists longer, viz.: to the close of the John Day epoch. It represents a distinct line of succession from that which we have been considering, and one which contains but two known terms. Next to Agriochœrus comes, in this line, the genus Coloreodon Cope, which outlasted its predecessor so far as is yet known. It commenced with it in the John Day epoch, and continuing into the North Fork beds, which are of later age, did not appear later. This series Leidy regarded as a family distinct from the Oreodontidæ. For the present I prefer the view of Gill, that it constitutes a subfamily, the Agriochœrinæ.

This genus presents us with one of the very few cases in the suborder Artiodactyla, in which the last premolar approaches (above) or accomplishes (below) identity of structure with the true molars. This degree of complication was attained at the same period by both the equine and rhinocerontic lines of Perissodactyla, and all existing members of that order exhibit it. In the Agriochœridæ it made a beginning, but soon disappeared from the earth, and no Artiodactyle has developed such permanent premolars successfully since.

In the characters of the skull this genus is less robust than the Oreodontidæ; but the general skeleton remains unknown.

Five species have been described which are referable to this genus, and two others are now added. One of the former is without premaxillary or superior incisor teeth, and I therefore regarded it as representing a distinct genus under the name of *Merycopater*. It, however, appears that no specimens exist in our museums which exhibit this part of the skull in other species of the genus, so it is absolutely uncertain whether Agriochœrus possesses those teeth or not. The species may then be distinguished as follows:

I. Otic bullæ compressed, base anteroposteriorly ovoid.

a. Foramen infraorbitale above junction of P-m. iii and iv.

Front narrower; internal wall of fourth premolar not complete.....*A. antiquus.*
Front wider; skull shorter and higher; internal wall of inferior P-m. iv complete.....*A. latifrons.*
aa. Foramen infraorbitale above junction of P-m. ii and iii.
Front medially concave, laterally descending to orbits; sagittal crest short.....*A. trifrons.*
II. Otic bullæ mammiform with triangular base.
Front convex; nasal bones acute posteriorly; fourth inferior premolar complete; infraorbital foramen above junction of P-m. iii and iv.....*A. guyotianus.*
III. Otic bullæ oblong, constricted at the middle.
Infraorbital foramen above junction of P-ms. ii and iii; front plane; nasal bones truncate posteriorly; postglenoid process robust.....*A. ryderanus.*

Besides the above, Leidy has described an *A. major** as near to the *A. antiquus*, but of larger size. Marsh has described a small species from the Uinta formation under the name of *A. pumilus.*† Lydekker figures and describes a superior molar tooth from India as probably belonging to this genus.‡ It is stated by him to have been found in the earlier pliocene formation. If this determination be correct, it represents the latest known species, as the *A. pumilus* of Marsh is the earliest. Owing to incompleteness in the descriptions of these species I cannot include them in the above synoptic table.

Agriochœrus antiquus Leidy.

Proceedings Academy Philadelphia, 1850, 121; 1853, 392; 1854, 157; 1857, 89. Ancient fauna of Nebraska, 1853, p. 24, Pl. I, figs. 5–10. Bronn Lethæa Geognostica, 1856, 933; Leidy Extinct Mammalia Dakota and Nebraska, 1869, 132, Pl. XIII, fig. 4.

White River epoch of Nebraska and Dakota.

Agriochœrus major Leidy.

Proceedings Academy Philadelphia, 1856, p. 164; 1857, 89. ?*Eucrotaphus auritus* Leidy, Owen's Report Geological Survey, 1852, p. 563, Pl. XV, figs. 1–3. Ancient Fauna of Nebraska, 1853, p. 56; Pl. VII, figs. 1–3. Bronn Lethæa Geognostica, 1856, 931.

White River formation of Dakota and Nebraska.

Agriochœrus latifrons Leidy.

Proceedings Academy Philadelphia, 1867, p. 32. Extinct Mamm. Dakota, Nebraska, 1869, p. 135, Pl. XIII, figs. 1–3.

White River epoch of Dakota and Nebraska.

*Extinct Mammalia of Dakota and Nebraska, p. 134.
†Amer. Journal Science and Arts, 1875, p. 250.
‡Paleontologica Indica.

Agriochœrus trifrons sp. nov.

This species is known to me by a single cranium of an immature individual. It lacks of perfection only the basioccipital, the pterygoid, and the alveolar border of the premaxillary bones. It retains the third and fourth deciduous premolars, while the third true molar is still in its alveolus, where it is exposed in place.

Although the specimen is immature, its characters will not permit me to place it with any other species known to me. I have specimens of like age of the *A. guyotianus*, and these are quite different. From *A. ryderanus* it differs in the form of its otic bulla, etc.

The muzzle and front form a flat horizontal profile, while the pariëtal region is convex. The profile descends gently to the supraoccipital border, or inion. The muzzle is compressed above and below the canine alveolus, and there is a concavity above the third and fourth premolars, and behind the foramen infraorbitale above this fossa the lachrymal region is convex. The nasal bones are lost, so that the form of their posterior suture cannot be ascertained. The frontal bones are gently concave in transverse section between two lines produced forwards from the anterior extremities of the temporal ridges, that is at the postorbital constriction of the cranium. These lines are represented by a rounded longitudinal angle, from which the frontal bone descends to the superciliary border on each side. A trace of this form is seen the *A. ryderanus*. The supraorbital borders diverge outwards and backwards to the postorbital processes. These are prominent horizontally, and are abruptly decurved at the apex. The temporal ridges enclose an urceolate area, having a gentle convexity in their direction before they unite at a point more posterior than in the other species, that is above a line connecting the anterior borders of the postglenoid processes.

The malar bone is slightly concave on the external face, and is moderately deep, and not thick. The squamosal part of the zygoma is rather slender, and does not rise above the postglenoid process. Its superior edge continues without interruption into the posterior temporal crests, and so into the supraoccipital. The postglenoid process is like that of *A. guyotianus*, narrow and produced downwards. Paroccipital lost. The otic bulla is large, its anterior edge extending anterior to the postglenoid process. It is nearly twice as large as in *M. guyotianus*, and extends much further forwards. It presents two flat sides, one external, the other outwards and forwards, and a convex side inwards and backwards. These sides meet at an angular edge below, which runs outwards and backwards. The sphenoid bone is convex between the bullæ. Basioccipital lost. The palatonareal border is convex, and is opposite the middle of the second true molar. In the mature skull it would be probably more posterior. The palate is everywhere concave in transverse section.

The frontopariëtal suture is broadly convex, and is opposite the anterior edge of the glenoid surface, and 25 mm. in advance of the sagittal crest. The anterior processes of the bone on each side of the nasals are wide and truncate, and do not extend beyond the interior suture of the lachrymal

bone. The latter is about as long on its superior sutures as it is deep at the orbit. It presents a distinct preorbital angle above a prominent tubercle. The occipito-pariëtal suture extends well forwards, 30 mm. in advance of the crest. The squamosal does not reach to the lateral occipital crest.

The infraorbital foramen occupies the position it has in the *A. ryderanus*. In a young specimen of *A. guyotianus* it has the same position as in the adult. The frontal foramina are about as far apart as each is from the supraorbital border. There is a postpariëtal foramen on the pariëto squamosal suture, and there are three postsquamosals, two of them near together, and near the posterior suture, the other below the postpariëtal foramen. *Foramen ovale* oval, about as large as the *F. rotundum*, and separated from the foramen lacerum by the produced base of the inferior ala of the sphenoid bone. Palatine foramen opposite the third deciduous premolar.

Superior canine teeth robust, bases of crown one-half lenticular, the posterior face truncate. A considerable diastema anterior to first premolar, and a short one behind it. Other teeth in continuous series. First and second premolars two-rooted; absolutely simple. Third and fourth crown of first of usual form. First true molar smaller than second. Enamel minutely roughened.

Measurements.	M.
Length from supraoccipital crest to canine inclusive	.180
" " " " " front of bulla	.036
" " " " " penultimate molar.	.108
" " " " " orbit (axial)	.105
" " " " " front of orbit	.126
" of sagittal crest	.046
" " superior molars (last included)	.076
" " premolars	.036
Diameters M. i { anteroposterior	.063
Diameters M. i { transverse	.014
Diameters M. ii { anteroposterior	.0165
Diameters M. ii { transverse	.020
Width of skull at postglenoid inclusive	.077
" " " middle of zygomas	.050
" " " fundus of canine alveolus	.038
" between canines	.020
" " second true molars	.033
" of skull at postfrontal processes	.076
" " " between anterior rims of orbits	.066

The label from this specimen is lost. It is, however, from Oregon, and to judge from the color, from the true John Day epoch, rather than the North Fork bed.

Agriochœrus guyotianus Cope.

Hyopotamus guyotianus Cope, Proceedings American Philosophical Society, 1878, p. 77. *Merycopater guyotianus* Cope, American Naturalist, 1879, p. 197, Proceeds. Amer. Philos. Soc., 1879, 375.

Three crania, one with nearly entire mandible, and numerous fragments with mandibles, represent this species in my collection. It is the most abundant species of this genus in the John Day beds of Oregon.

The cranium is of peculiar form. It is elongate from the orbits backwards. The muzzle is elevated and compressed, so that the profile is horizontal, with subordinate irregularities. The occiput is therefore low as compared with the muzzle. The zygomata are rather slender, and are not expanded. The side of the muzzle is concave just below the superior border of the maxillary bone and above the fundus of the canine alveolus. The inferior part of the maxillary is concave from below the anterior border of the orbit to the line of the canine alveolus. The region above and anterior to the lachrymal bone is convex, leaving the flat nasal bones a little depressed. The frontal has a convex swelling on the middle line just posterior to the frontal foramina, from which point the surface slopes gradually and evenly to the supraorbital borders, and not in two planes, as in *A. trifrons*. At the front of the orbit the section of the frontal bone is convex at the sides and a little so at the middle. The supraorbital border is short and concave, not long and straight as in *A. trifrons*, and the postfrontal process is moderately prominent, and is not decurved. The anterior temporal ridges do not reach them. The former converge in nearly straight lines at an acute angle to a long sagittal crest. This in turn bifurcates into two very prominent posterior temporal crests, which overhang the occipital condyles. The brain-case is an elongate-oval, and the olfactory portion is long and narrow, but not especially constricted at any one point. There is a prominent small tuberosity at the inferior part of the lachrymal bone ; above it the preorbital border is not defined as far as the beginning of the supraorbital. The postfrontal process originates below the anterior temporal surface which is continued along its posterior edge. The malar bone is concave on its external face. The zygoma is compressed, and has a long low superior convexity behind. Its crest continues into a fine, low, posttemporal crest, which turns posteriorly above to its prominent posterior expansion above mentioned. The latter turn outwards at the apices, and send a low ridge downwards towards the occipital condyle. Below, the latter form a low angle on each side, which separates a median from a lateral plane. Above, the occiput is deeply concave, and has a trace only of median keel.

The basicranial axis is flat and rather wide between the otic bullæ. The occipital condyles have distinct inferior boundaries which are separated by a flat interval. The posttympanic region is wide, and is bounded inferiorly by the deep styloid fossa. This is surrounded internally and posteriorly by the funnel-shaped base of the paroccipital process, which extends first posteriorly as a longitudinal lamina, and then outwardly. Its

edge terminates in a rough band which curves upwards and backwards to a point above the line of the occipital condyle. It is separated by a shallow groove from the corresponding posttympanic ridge. The tympanic bone is not so long as in the species of Oreodontinæ, and presents a tuberosity externally. Like the paroccipital its base unites with the otic bulla. The bulla is small. Its base is extended towards the postglenoid process, but it is well separated from it, and does not reach the line of its anterior border. It presents a face anteriorly, and one inwards. The postglenoid process is narrow transversely, the depth and width being equal, and is elongate downwards.

The coronoid process of the mandible is short, but has a base extended anteroposteriorly. The articular face of the condyle is convex anteroposteriorly, and is extended downwards on the inner side behind. The horizontal ramus is slender, and has a straight inferior border. (The angle is broken away from this specimen.) The symphysis is oblique and nearly straight in profile. It is moderately elongate, and has the suture persistent. There is a tuberosity looking downwards from its posterior extremity, where it is rounded-compressed.

The facial part of the lachrymal bone is longer than deep, and the lateral anterior part of the frontal is wide and obtuse, and extends anterior to the lachrymal. The nasals extend posteriorly to terminate in an acute angle which is above the anterior edge of the orbit. The frontoparietal suture extends across the space between the anterior temporal ridges at a point half way between the anterior border of the orbit and the anterior glenoid margin. The malomaxillary suture has no anteroinferior process. The mastoid forms a distinct mass between the exoccipital and squamosal. The sutures are largely coössified.

The infraorbital foramen is above the contact of the third and fourth premolars. The space between the frontal foramina is about one-sixth the interorbital width. There is a large postparietal foramen on the parietosquamosal suture, and there are two small postsquamosal foramina, in line above the posttympanic tuberosity. The mastoid foramen is small, and is not situated in a fossa of any extent, as is the case with the species of the Oreodontinæ. There is a large foramen intermediate in position between that of the anterior condyloid and the jugular. Anterior and a little external to it and slightly elevated between the confluent base of the paroccipital process and the otic bulla is another foramen, perhaps the jugular. Between the posterior base of the bulla and the basisphenoid, is a smaller foramen, probably the carotid. The other foramina are yet concealed by the matrix.

The teeth do not differ in their form from those of other species of the genus. The second and third premolars have triangular bases, the second the narrower. The first has two roots. It is accidentally lost from one side, which circumstance led me to suppose at one time that this species has but three premolars above. The fourth premolar has its posterior external V well developed, though a little smaller than the anterior. In the

specimen now described, the posterior internal rudimental cusp is quite well developed; in the two other specimens now before me it is not so large. The superior canine is elongate, and not very robust, and its convex anterior border is directed partly posteriorly at the apex. The enameled portion of the crown is quite short. The premaxillary bones are narrow and weak, and are separated so as not to be in contact on the middle line. Its border displays two minute alveoli, from which teeth have been shed. I do not suppose that their presence is constant in the species. The external alveolus is twice the diameter of the internal. The inferior incisors are of normal number, but are very narrow, and much crowded. The canines are very narrow, but are longer than the incisors. The first inferior premolar is more caniniform than in any other species of Oreodontidæ known to me. The crown is a compressed oval in section, and is not expanded at its base. It is enameled to within 5 mm. of the alveolar border. A considerable diastema separates it from the second premolar. The description of the remaining teeth I take from a separate ramus of similar dimensions, as they are concealed in the type by their position in juxtaposition with the cranium. The cusps of the true molars are pyramidal and acute, and entirely separate from each other. The external faces of the external are convex, their internal faces flat. The external faces of the internal are convex, the internal faces concave at the base, and convex near the apex. The anterointernal angle of the posteroexternal cusp extends to the base of the anterointernal cusp. The only difference between the first true molar and the fourth premolar, is that the anterior crest of the anteroexternal cusp is continued round to the front of the anterointernal cusp, and to the internal side of the crown; and the apices of the two anterior crests are separated by a shallow notch. The second inferior premolar has two roots. The heel of the third true molar is well developed, and is convex posteriorly.

Measurements.	M.
Length from occipital condyles to postglenoid process	.038
" " " " " preglenoid border	.058
" " " " " postfrontal process	.104
" " " " " canine, inclusive	.226
" " orbit to canine inclusive	.085
" of mandibular ramus from condyle	.176
" "symphysis mandibuli below	.049
Width of occipital condyles inclusive	.046
" " occiput above	.045
" "between otic bullæ	.016
" "at postglenoid processes inclusive	.079
" "of skull above glenoid surfaces	.100
" " " below orbits	.099
" " " between orbits	.068
" " " at fundus of canine alveoli	.040

Measurements.	M.
Width of skull between last upper molars, inclusive	.070
Depth of occiput to foramen magnum	.043
" " " " basioccipital bone	.058
" " skull at last superior molar, exclusive	.058
" " " " first premolar, exclusive	.055
" " ramus mandibuli at front of M. iii	.035
" " " " " " " P-m. iv	.027
" " zygomatic arch above glenoid facet	.027
Diameters of base of crown of superior canine { anteroposterior	.009
Diameters of base of crown of superior canine { transverse	.0085
Length of superior diastema	.022
" " premolar series	.039
" " true molar series	.043
Width of premaxillary bones together	.043
Diameters of base crown inferior P-m. i; anteroposterior	.0085
Length inferior diastema	.015
" " last three premolars	.031
" " true molars	.046
" " last true molar	.021
" " third premolar	.009
" " fourth	.012
Horizontal diameters of otic bulla { anteroposterior	.019
Horizontal diameters of otic bulla { transverse	.017

The specimens of this species which I have seen, are from the John Day river, and were obtained by Messrs. Sternberg, Wortman and Davis. The skull from which the above description was taken is the most perfect one of the genus Agriochœrus which has yet been found.

Agriochœrus ryderanus Cope.

Coloreodon ryderanus Cope, Bulletin U. S. Geological Survey Territories, vi, p. 173.

This species is represented in my collection by three nearly complete skulls without mandibular rami. While of the general size of the *A. guyotianus*, this species displays various well marked peculiarities. The most important of these are (1) the shape of the otic bulla, in which it differs from all other known Oreodontidæ; (2), the position of the infraorbital foramen, in which it resembles in this genus only the *A. trifrons;* (3), in the form of the nasal bones posteriorly, in which it differs from the species where this part is known; (4), in the form of the palatonareal border; (5), in the form of the postglenoid process; (6), in the outline of the section of the frontal bone.

Agriochœrus ryderanus has the muzzle compressed laterally and flattened on top, as seen in the *A. guyotianus* and *A. trifrons*, and the side of the

muzzle has three distinct fossæ. The largest of these is above the position of the fundus of the superior canine alveolus; the second is below the fundus; and the third is behind the position of the infraorbital foramen, and above the third and fourth premolars, and the first true molar. The lachrymal region is plane, and the nasals are flat. The frontal bone is nearly flat in section between the posterior borders of the orbits, but each is decurved to the lachrymal opposite the anterior border of the orbit. There is no indication of the three planes of the infraorbital region characteristic of the *A. trifrons*, nor of the median convexity of the *A. guyotianus*. The anterior temporal ridges commence about the middle of the width of each frontal bone, and unite after a shorter independent course than they have in *A. guyotianus* into a long, narrow saggital crest. This bifurcates posteriorly into two prominent lateral crests, which are directed downwards and soon terminate, but which send forwards and downwards a delicate posttemporal crest. This passes without interruption into the superior edge of the zygomatic arch. This arch is not expanded either upwards or laterally, and is rather weak. The external face of the malar bone is gently concave, and the inferior edge is rather wide, is truncate, and grooved along the middle. The occiput is deeply concave between the crests, and below them is gently convex. The superior edge of the foramen is deeply notched at the middle, much as in *M. guyotianus*.

The occipital condyles are large, and their inferoanterior angles are produced horizontally for a short distance, forming short processes which are separated by a concavity of the basioccipital bone. The latter is plane below, but anteriorly develops a low meridian angle, which, widening on the sphenoid, causes its inferior face to be convex. The posttympanic element is distinguishable from the mastoid by a superficial groove, and a slightly free apex, and the mastoid from the paroccipital by a slight groove. The external base of the paroccipital extends but 5 mm. external to the line of the external border of the occipital condyles, and is therefore much less prominent than in the majority of species of Oreodontinæ. The base of the paroccipital has a posterior and an anterior face, nearly at right angles with each other. The latter is continued into the pinched posterior prominence of the auditory bulla, and encloses on its external side, with the apex of the posttympanic, the deep stylohyoid fossa. The tympanic bone is represented by a tuberosity below the meatus, and a laminar expansion on the posterior face of the postglenoid process. The otic bulla's long axis is inwards, and a little posterior from the internal side of the postglenoid process, from which it is separated by a narrow interval. The bulla is constricted at right angles to its long axis, in two parts. The external part is subglobular with the side next the postglenoid process flattened. The internal part is roughened, displays a flat side posterointernally, and has an apical keel which extends posteriorly and a little externally into the base of the paroccipital processes. This form is not known in any other species of the family. The postglenoid process is more robust than in either *M. guyotianus* or *M. trifrons*. Its width and thickness are equal,

and are a good deal longer than its height; in the species named the height equals the other measurements. The pterygoid ala rises opposite the middle of the end of the glenoid surface, and the angle of its junction with the pyramidal process of the palatine is considerably in front of the middle of the trough of the posterior nares. Its edge posterior to this angle is shallowly grooved. The palatonareal border differs from that of any other species of the family known to me. It is acute in front, forming a Gothic arch, its apex being opposite the middle of the superior third true molar. In a young *M. guyotianus*, the only specimen of that species in which it is perfectly preserved, it is rounded, and extends to the posterior part of the second true molar. In an adult specimen, where the middle portion of the margin is lost, it extended at least as far forwards; but its form is uncertain. The palate in the *A. ryderanus* is strongly concave throughout.

The lachrymal bone has a different form from that of a *A. guyotianus*, more resembling that of *A. latidens* figured by Leidy. Its anterior superior angle is not produced, and its outline is a little deeper than long. The anterior lateral prolongation of the frontal extends beyond it by nearly its width, and is wide, and terminates in an obtuse angle. The posterior edge of the nasals is broadly rounded, truncate at the middle, and is situated much in advance of the frontal foramina. The pariëtal is in contact with the alisphenoid. The squamosal does not extend beyond the vertical line from the base of the paroccipital process.

The infraorbital foramen is above the anterior edge of the third superior premolar, a position only seen elsewhere in the genus *A. trifrons*. The superior border of the orbit is concave and short as in *A. guyotianus*, and not straight and flat as in *A. trifrons*. The frontal foramina are above their middle, and their distance apart goes 4.5 times into the interorbital width. There is a large postpariëtal foramen on the pariëtosquamosal suture, and a large postsquamosal immediately below it. This arrangement differs from that seen in the other species here described, where there are two or three postsquamosals well posterior to the postpariëtal. Mastoid foramen small. There are two palatine foramina on each side of the mouth, one opposite the posterior edge of the second premolar, and one opposite the posterior part of the fourth premolar. The anterior condyloid foramen is large. On one side is a small posterior condyloid, the only occurrence I have met with in the family. The foramen lacerum posterius is not divided into three foramina as in the *A. guyotianus*, but remains open as in the species of *Eucrotaphus* and *Merycochœrus*. It shows its nearer affinity to the first named species, however, in its triradiate outline; and in the three grooves of the side of the bulla, which correspond to two of the three foramina. The *f. lacerum anterius* is not large, and is oblong in shape. The ovale is rather small, and is entirely bounded on the inner side by the pterygoid ala of the sphenoid. The *f. rotundum* is large and rather posterior. It is not bounded below by a transverse shoulder as is seen in the species of Merycochœrus, but is continued into a longitudinal groove, whose

external wall is longer than in any of the other genera of the family, extending to a point half-way between the inferior edge of the foramen and the middle of the last superior true molar tooth. It is curved both inwards and downwards just posterior to the foramen.

The superior molar teeth do not differ from those of *M. guyotianus*, *M. antiquus* and *M. latifrons*. The canines are very robust, and are separated from the first true molar by a considerable diastema.

Measurements.	M.
Length from occipital condyles to line of postglenoid processes	.046
Length from occipital condyles to line of preglenoid border	.060
Length from occipital condyles to line of postfrontal process	.110
Length from occipital condyles to line of canines, inclusive	.220
Length from orbit to canine inclusive	.076
Width of occipital condyles inclusive	.050
" " occiput at paroccipitals	.031
" between otic bullæ	.015
" at postglenoid processes inclusive	.093
" of skull above glenoid surfaces	.110
" " " below orbits	.094
" " " between orbits	.064
" " " at fundus of canine alveoli; about	.029
" " " between last upper molars, inclusive	.080
" " palate at second true molars	.033
" " " " third premolars	.031
" between superior canine	.021
Depth of occiput to foramen magnum	.038
" " " " basioccipital	.057
" " skull at last superior molar exclusive	.050
" " " " first premolar, exclusive	.046
" " zygomatic arch above glenoid facet	.021
Diameters base crown superior canine { anteroposterior	.014
Diameters base crown superior canine { transverse	.012
Length diastema to first premolar	.0185
" premolar series	.0365
" true molar series	.045
Diameters P-m. iv { anteroposterior	.011
Diameters P-m. iv { transverse	.014
Diameters M. i { anteroposterior	.014
Diameters M. i { transverse	.015
Diameters M. iii { anteroposterior	.018
Diameters M. iii { transverse	.021

The skulls of this species came from the John Day bed of the John Day river, Oregon, and were found by Mr. J. L. Wortman. The species was established on an immature individual. The adults show that it belongs to this genus.

COLOREODON Cope.

Proceedings American Philosophical Society, 1879, p. 375.

Superior premolars three, the fourth with two external Vs, no facial vacuities.

The mandibles of the species of this genus are unknown, so that the character of the inferior dentition is unknown. The otic bullæ are also destroyed in all the specimens, so that their character is unknown.

In its reduced dental formula this genus represents one stage of that specialization which Owen has shown, has overtaken all the modern types of Mammalia. In this series this process seems to have stopped at this point, and not to have gone further, as the entire line has come to an end.

The first superior premolar probably exists in a rudimental condition for a short time, and is early shed. The same state of things has been found to exist as an abnormality on one side in the *Agriochœrus guyotianus*, and may be found again, but not so as to invalidate the characters of the genus Coloreodon.

Two well-marked species of this genus have been described, which differ as follows:

Smaller; palatonareal border opposite posterior cusps of second true molar; sagittal crest anterior, commencing opposite optic foramina ..... *C. ferox.*

Larger; palatonareal border opposite posterior cusps of third true molar; sagittal crest posterior, commencing opposite preglenoid border ..... *C. macrocephalus.*

Coloreodon ferox Cope. Fig. 1, p. 505.

Proceedings American Philosophical Society, 1879, p. 375.

The size of *Oreodon culbertsoni*. Known from one skull from the North Fork of the John Day river, Oregon. C. H. Sternberg.

Coloreodon macrocephalus Cope.

Proceedings American Philosophical Society, 1879, p. 376.

Size of the *Eucrotaphus major*. The typical skull is from the North Fork of the John Day river. A second skull, lacking all the parts posterior to the anterior origin of the sagittal crest, is undistinguishable from the first. It was found at the "Cove" of the John Day river, Oregon. Both were obtained by Mr. J. L. Wortman.

GENERAL CONCLUSIONS.

From what is now known of the history of the Oreodontidæ, the following conclusions may be drawn. These are especially instructive as far as they go, since they involve the causes of the rise, great development, decadence and extinction of one of the best-marked types of Mammalia the world has seen. The history of this type involves more or less the history of the life of the North American continent during the Miocene epoch of Tertiary time. It moreover involves the laws which regulate the vital success of all types of life, and which express the causes of multiplication, of energy, of weakness, and of sterility.

Two lines of the family, the *Oreodontinæ* and the *Agriochœrinæ*, come to light simultaneously in geological time, the White River epoch, or the Oligocene. The latter is a higher type than the former in its more complex fourth premolars, while it is inferior in the non-closure of the orbits posteriorly. It may then be regarded as a parallel line. It has but two generic types, while the Oreodontinæ present us with seven. So far as yet known, the Agriochœrinæ did not continue as long as the Oreodontinæ, as will be shown in tabular form below.

In the progressive modifications of the Oreodontinæ series, the first step was the inflation of the otic bulla (genus Eucrotaphus). This was succeeded by the coössification of the premaxillary bones (genus Merycochœrus). These changes were accompanied by a regular increase in dimensions. The species of Merycochœrus are all of the largest size, and there are no small ones. The smallest species of Eucrotaphus are equal to the largest ones of Oreodon. The fourth genus Merychyus, while it loses none of the points already gained, shows a deficiency in its facial walls where vacuities appear. There is the greatest range of size here: with one species (*M. major*), as large as any of the Merycochœri, we have another as large as the usual Eucrotaphi (*M. zygomaticus*), and several one degree smaller, or as large as the largest Oreodons. In the next genus the facial vacuities have attained to an enormous size. The premolar teeth become smaller, and the weakness of the narrow symphysis of the lower jaw is made up for by its coössification. The size is reduced from equal to the smallest Merychyi, to that of the smallest Oreodons (genus Leptauchenia). In the next stage (genus Cyclopidius) the superior incisors disappear. Finally, the lower jaw is so reduced in front that it loses both incisors and premolars, in spite of its symphyseal coössification (genus Pithecistes).

The species may be thus arranged in accordance with their distribution in time.

White River Epoch. Oreodon gracilis; O. affinis; O. culbertsoni. Eucrotaphus jacksoni; E. major. Agriochœrus antiquus; A. major; A. latifrons.

John Day Epoch. Eucrotaphus jacksoni; E. major. Merycochœrus superbus; M. leidyi; M. chelydra, sp. nov.; M. macrostegus, sp. nov

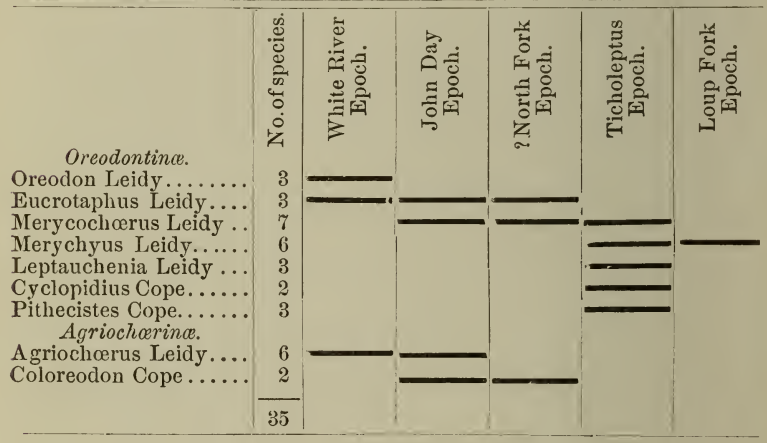
Agriochœrus guyotianus; A. trifrons, sp. nov.; A. ryderanus. Coloreodon macrocephalus.

North Fork of John Day River Epoch. Eucrotaphus trigonocephalus, sp. nov.; E major. Coloreodon ferox; C. macrocephalus.

Ticholeptus Beds. Merycochœrus montanus, sp. nov.; M. rusticus; M. proprius. Merychyus arenarum, sp. nov.; M. pariogonus, sp. nov.; M. zygomaticus. Cyclopidius simus; C. emydinus, sp. nov. Leptauchenia major; L. decora; L. nitida. Pithecistes brevifacies; P. heterodon; P. decedens, sp. nov.

Loup Fork Beds. ? Merychyus elegans; M. medius; ? M. major.*

The stratigraphic relations of these species may be represented under their generic heads in the following table:



On the Structure of the Skull in the Elasmobranch genus Didymodus.

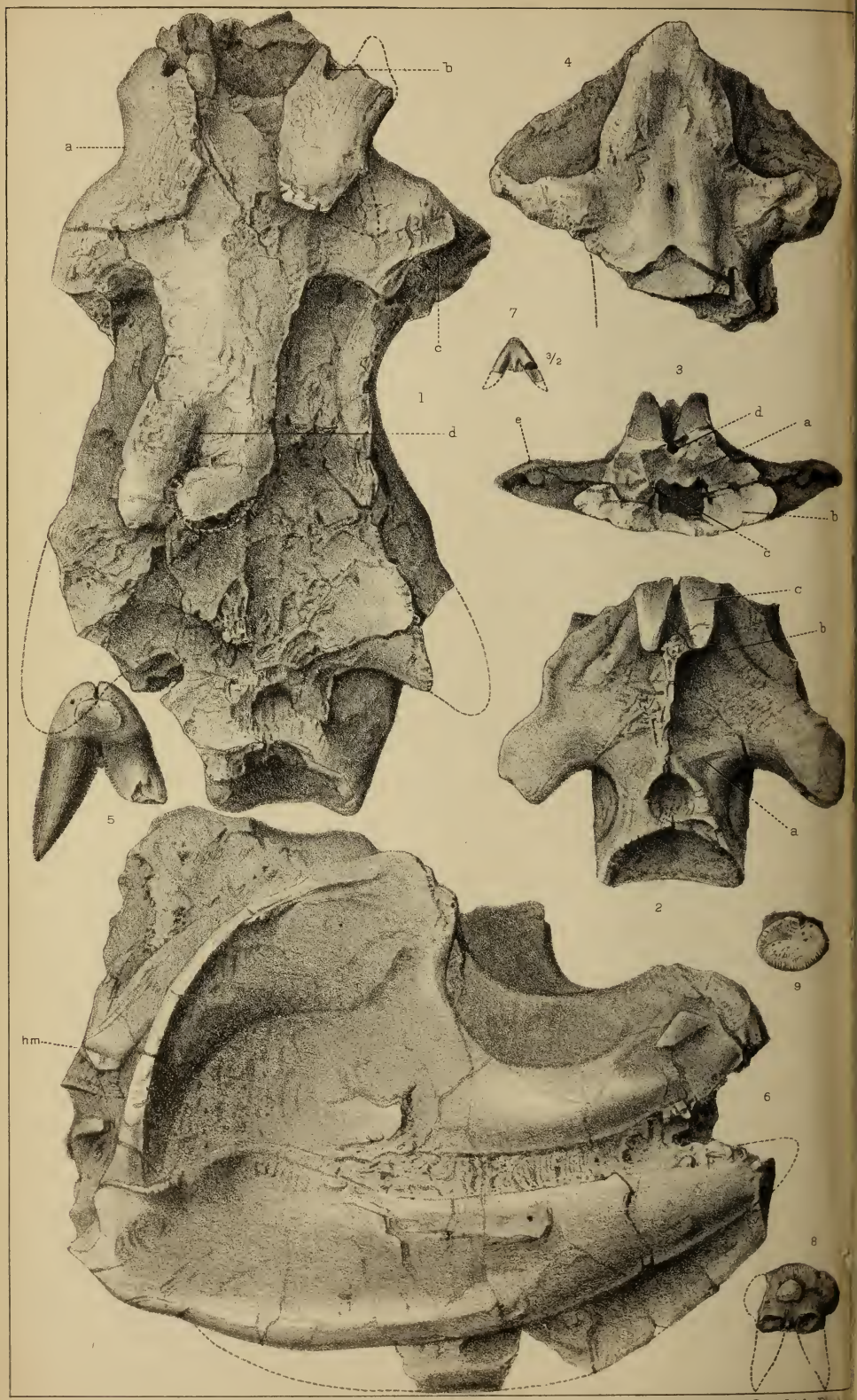
By E. D. Cope.

(*Read before the American Philosophical Society, March 7, 1884.*)

The genus *Diplodus* was described by Agassiz from specimens of teeth from the European Coal Measures. In America, Newberry and Worthen† have described four species from the Carboniferous of Illinois and Ohio; and I have reported two species from the Permian beds of Illinois and Texas. Recently Mr. Samuel Garman has described a shark, said to have been taken in the Japanese seas, under the name of *Chlamydoselachus*

* The questions refer to the geological age.

† Geology of Illinois, vol. ii.



T. Sinclair & Son, Lith. Phila.

SKULL OF DIDYMODUS.

anguineus, whose teeth, as represented, do not differ generically from those of Diplodus. This is an interesting discovery, indicating that this genus, and not Ceratodus, is the oldest type of vertebrate now known in the living state.

My collections from the Permian beds of Texas include not only numerous teeth, but jaws and crania. Among these I recognize two types of teeth, which I cannot distinguish from those of the *D. compressus* Newb., and *D. gibbosus* Agass. Whether these species belong to the same genus, is a question which I will discuss at the close of this article. I provisionally refer the *D. compressus* to a distinct genus, Didymodus, and will so call it in this article.

The determination of the characters of this genus is a point of much interest The teeth resemble those of the existing sharks more than do those of any other genus of the Palæozoic ages, but the antecedent improbability of the modern type having existed at such an early period of the earth's history, is shown to be well founded by the present investigation, which also throws much light on the question of the general phylogeny of the fishes.

I. Description.

Twelve more or less complete crania of species of Didymodus are in my collection, and one set of jaws with small teeth and part of the cranium attached. One of the crania, unfortunately much broken, exhibits also some large teeth. All were found by the late Jacob Boll in the Permian beds of Texas.

The skull of this species forms a continuum, which, however, displays distinct segments. First, however, as to the tissue of which it is composed. Both on the surface and in transverse fractures, it is more or less finely granular, the granules distinctly visible to the naked eye. These granules are composed of gypsum, as is also the matrix of a darker color in which they lie imbedded. Two hypotheses may be entertained regarding this structure. *First*, These granules may be regarded as the casts of coarse cartilage cells, and the matrix be in the place of the intercellular cartilage, replaced like the woody tissue in petrified wood. *Second*, The granules may be looked upon as replacements of osseous granules, such as cover the chondrocranium of most Elasmobranch fishes, while the matrix may be a replacement of the cartilage. The latter hypothesis is the more probable of the two, for two reasons: First, There is little probability of an unsupported chondrocranium retaining its form sufficiently long to permit the filling of its cells with a mineral deposit. Second, The granular type of ossification is well known in existing Elasmobranchs. It is only necessary to believe that the chondrocranium is penetrated by this kind of ossification. This state of things exists in the jaws also, which I describe later. This structure has already been observed by Kner in the genus Pleuracanthus.

The osseous cranium is abbreviated anteriorly, and elongated posteriorly,

The orbit occupies part of the anterior third of the length. It is bounded in front by an obtuse preorbital process, and posteriorly by a laterally expanded and decurved postorbital process. The latter bears an articular facet on its posterior and inferior face. The top of the muzzle is excavated by a fontanelle which does not extend posterior to a line connecting the preorbital processes.

There is a prominent cup-shaped occipital condyle. On each side of the cranium a short distance anterior to it, is a prominent process extending outwards and a little backwards, which is excavated on its inferior side, but whose posterior side is decurved, so that the inferior concavity looks partially forwards. Into this cavity, and abutting against the decurved posterior edge, is a lateral process of the basal axial bone of the skull, which I take to be homologous with the lateral alæ which occupy the same position in the sharks. Anterior to this junction no doubt the hyomandibular bone was suspended, for I suspect that it was articulated to a small condyle which is wedged into the fissure between the inferior and superior elements described, a centimeter anterior to their posterior extremities. This condyle is a distinct element of a subglobular form.

The interorbital plane is continued posteriorly, bounded on each side by a depression which probably corresponds to the temporal fossa of higher vertebrates. The edges of this plane are thus well within the lateral borders of the cranium. The plane rises a little posteriorly, and is split into two narrow wedge-shaped processes, which project freely upwards and backwards. The rather short remaining part of the roof of the skull has a keel or sagittal crest on the middle line, which descends gradually to the foramen magnum.

The base of the skull forms a continuum from the edge of the large occipital cotylus to the acuminate anterior extremity. The lateral basal alæ are subcylindric, and are separated from the basicranial axis by a fissure for a short distance, and then unite with it. Two or three foramina anterior to this reunion, are in line with the defining fissure just mentioned. The basis cranii sends out a process on each side below the postorbital processes, giving a cross-shape to this part of the base of the skull. Anterior to this point it is free from other elements and contracts to an acuminate apex.

The cranium is segmented, but a clean specimen is necessary to permit the straight sutures to be seen. In the first place, there is a distinct occipital bone, which includes exoccipital and basioccipital elements combined. The latter includes the large occipital cotylus, as in the Rhachitomous batrachian Trimerorhachis, and differs from the structure seen in the Lepidosirenidæ, where exoccipital elements only are present. The occipital extends but a short distance on the inferior face of the axis. It is preceded directly, and without imbrication, by a continuous axial element. If we recognize in the granular character of the tissue evidence of true ossification of the chondrocranium, we have here true continuous sphenoid and presphenoid bones.

Returning to the superior face of the cranium, we observe that the exoccipital elements form a wedge-shaped body, divided on the middle line by suture, with the apex forwards. Traces of this division are figured by Gegenbaur as present in Heptanchus.* Anterior to this the middle of the cranial roof is apparently occupied by another triangular bone with the base posterior and the apex anterior, and concealed beneath the free extremity of the element in front of it. The lateral sutures only are distinguishable, appearing as grooves (fig. 2). This is the pariëtal bone. External to this and the occipital, and filling the space behind as well as anterior to the postero-lateral angle of the pariëtal, is the element which is produced outwards and backwards as already described. Were I describing a true fish, this bone might be intercalare (epiotic) or pterotic. Perhaps it is both combined, or it may be the cartilage bone called by Günther, in Ceratodus, the "tympanic lamina."† The element anterior to the pariëtal is the cartilaginous representative of the frontal, and the fact that it terminates posteriorly in two free processes is significant of the true homology of the bones which terminate in like manner in the crania of the Lepidosirenidæ.‡ In this family and in the Ceratodontidæ these bones are more or less separated on the middle line by the median posterior element. In Ceratodus the separation is wide; in Lepidosiren the interval is uninterrupted, but narrow in front. In Protopterus these elements are in contact on the middle line, but diverge posteriorly. Bischoff, Stannius§ and Günther identify these elements with the frontals in the genera they have described. Huxley‖ calls them supraorbitals, so that it becomes necessary to name the median posterior element a fronto-pariëtal, as a combination of two bones usually found distinct in fishes. The furcate structure of the frontal cartilage in Didymodus goes to show that the identification by Bischoff and Günther is the correct one. There are also in this genus distinct paired membrane bones which do not take part in the bifurcation in question, and which appear to represent the frontals of Ceratodus. Each of these is a flat, subcrescentic supraorbital plate, which has a concave superciliary border. It is separated by a considerable interval from its fellow of the opposite side. Its anterior extremity is notched by a fossa which I suppose to represent the anteterior (posterior in position) nostril. The ? frontal of the right side is displaced, and appears as a lamina lying on the frontal cartilage, showing that it is a membrane bone. From its relation to the nostril the question arises, whether it be not the homologue of the nasal.

For hyomandibular bone, palatopterygoid arch, and mandibular arch, we have to rely principally on one specimen. On one of the skulls, two

* Ueber den Bau des Schedels der Selachier, 1872, Pl. I.

† Philosophical Transactions of the Royal Society, 1871, p. 511, indicated on the plates by the letter *d*.

‡ *Lepidosiren paradoxa* by Bischoff, Prof. in Heidelberg; Leipsic, 1840.

§ Handbuch der Anatomie der Wirbelthiere; Rostock; Erstes Buch, die Fische, 1854, p. 49.

‖ Anatomy of Vertebrated Animals, 1871, p. 145.

curved rib-like bones lie parallel and divergent posteriorly on the right side of the frontal, in the temporal fossa. I cannot identify them. They are not present on the opposite side. As already described, there is a facet on the infero-posterior face of the postfrontal process. This indicates the point of articulation of the palatopterygoid arch, as it exists in the group Opistharthri of the sharks as defined by Gill, and as is clearly proven by the specimen now to be described.

This includes the entire palatopterygoid and mandibular arches of one side, and the greater part of that of the opposite side, together with a considerable part of the right hyomandibular bone and probable extremity of the ceratohyal. The anterior parts of both jaws support numerous small teeth, which closely resemble those described by Agassiz as belonging to his *D. gibbosus*. They differ from those of the *D. compressus* in their smaller size. The palatine bones do not project much beyond the mandible, which, taken in connection with the form of the muzzle above described, renders it probable that the mouth was nearly terminal.

In the palatopterygoid arch there is no noticeable separation or suture between the palatine and pterygoid elements. The inferior border of the palatine is swollen below the orbit; its superior plate rises into a strong suborbital ala, which is concave externally, with thin superior edge. This edge rises posteriorly, giving the outline an elevated convexity, whose greatest upward prominence is above a point a little posterior to the middle of the jaw, and which probably articulated with the postorbital process of the cranium. Its surface gives indication of an articular surface appropriate to the corresponding one of the cranium. The superior border then descends rapidly to a vertical posterior border, which forms a somewhat prominent rim. This descends to the mandible, forming a regular ginglymus, the mandible bearing the cotylus. The mandible is rather robust; its inferior edge is rather thin, and becomes incurved anteriorly. Its superior border is regular, except that it rises a little at the coronoid region, and is impressed, corresponding with a concavity of the surface, and arch of the border of the pterygoid region, just anterior to the posterior prominent ridge which forms its posterior edge.

The hyomandibular bone is only exposed for its inferior half. It issues from behind the palatopterygoid as a narrow shaft with obliquely truncate extremity.

It is thus evident that the arrangement of the jaws is as in the two exceptional existing genera, Hexanchus and Heptanchus.

The external nostril already referred to, is a distinct, rather small fossa, on the lateral part of the superior face of the muzzle, near the extremity of the osseous portion. It is visible on both sides of the best-preserved specimen. It is continued forwards as a shallow groove. At the apex of the muzzle, is a fossa looking downwards, where roofed on each side by the ? nasal bones, which may represent the posterior nasal cavity. Or the latter may probably be represented by a lateral fossa just in front of the preorbital process. In either case it is evident that the nares are separated,

and that the posterior one cannot be said to be within the oral cavity, as is the case in the known families of the Dipnoi. It is probable that there is a frontoparietal foramen at the posterior bifurcation of the frontal bones, corresponding to the conarium or pineal body of the brain. In a cranium broken across just anterior to the bifurcation, a canal passing forwards and downwards is exposed. There is a foramen, or possibly only a deep fossa on each side of the middle line on the occipito-sphenoid suture. The foramen magnum is rather small and opens upwards. Its border displays no articular surfaces. At the middle of a line connecting the posterior borders of the postorbital processes is a small shallow fossa, or probably foramen, from this there extends on each side backwards and outwards, a shallow groove apparently for a vessel, which terminates at the anterior one of three foramina already mentioned as in line with the fissure which distinguishes the lateral ala of the basicranial axis posteriorly. A similar groove connects the first and second of these foramina, and in one specimen the groove from the median foramen joins this connecting groove. In front of the median foramen is a rather larger one on the median line, situated at the fundus of a short longitudinal groove. It is placed just posterior to a line connecting the preorbital processes. The grooves easily become obsolete by weathering.

II. Affinities.

In determining the systematic position of this animal, it will be convenient to take a survey of the characters of the primary divisions of the fishes. In 1840 Bischoff published the first account of the osteology of Lepidosiren. In this description he called the frontal bones malars with a question, and the pariëtals frontopariëtals. He described the skull as having an os quadratum. In 1854, Stannius in the Handbuch der Zoötomie* correctly determined the frontals and pariëtals, and stated further that the "lower jaw and hyoid bone articulate directly with continuous processes of the chondrocranium." This appears to be the first correct description of the cranial structure of the Dipnoi. In 1864,† Huxley restated the view of Stannius as to the nature of the mandibular articulation; adopted the opinion of Bischoff that the frontal is a frontopariëtal, and took a new position in calling the frontals supraorbitals. He also restates in general, the description of the skull of the Holocephali already given by Stannius.

The system of Johannes Müller, adopted by Stannius, was a great improvement over preceding ones. It embraced, however, the error of including the Holocephali in the same sub-class (Elasmobranchi) with the sharks. This was adopted by Gill in 1861,‡ by Huxley in 1864§ and in 1871.‖ All of these authors adopt at these dates the sub-class Ganoidea.

* Erstes Buch, die Fische, p. 49.
† Elements of Comparative Anatomy, p. 210.
‡ Catalogue of the Fishes of the East Coast of North America, p. 24.
§ Elements of Comparative Anatomy.
‖ The Anatomy of Vertebrated Animals, p. 120.

In 1871* the writer gave the following as the primary divisions of the sub-class Pisces: Holocephali, Selachi, Dipnoi, Crossopterygia, Actinopteri. The Holocephali was raised to an equivalency with the other sub-classes on account of the absence of distinct hyomandibular bone. The Dipnoi were defined by the median pelvic element, by the distichous arrangement of the segments of the pectoral and ventral fins, when present, on a median axis, and by the supposed presence of a distinct hyomandibular bone. The latter definition must be abandoned, for though an ossification exists, it has been shown by Stannius, Huxley and Günther, to be merely a deposit in the continuous chondrocranium. The sub-class Crossopterygia was substituted for the sub-class Ganoidea of Agassiz and Müller, as the latter was believed to have no actual existence as a division of fishes. After comparing the osteology of Polypterus, Lepidosteus and Amia, I remark (p. 320) "It is thus evident that the sub-class Ganoidea cannot be maintained. It cannot be even regarded as an order, since I will show that Lepidosteus, Accipenser, and Amia, are all representatives of distinct orders. I hope, also, to make it evident that Polypterus should be elevated to the rank of a sub-class or division of equal rank with the rest of the fishes and with the Dipnoi, already adopted." The sub-class Ganoidea has not yet fallen into disuse, but there are strong symptoms that it will do so.† Among others I select the following extract from Huxley's paper on the ovaries of the smelt, published in 1883.‡

"As is well known, Lepidosteus presents an example of a Ganoid with oviducts like those of the higher Teleostei; in *Osmerus*, on the other hand, we have a Teleostean with oviducts like those of the ordinary Ganoidei. It is tolerably obvious, therefore, that the characters of the female reproductive organs can lend no support to any attempt to draw a sharp line of demarkation between the Ganoids and the Teleosteans.

"Boas has recently conclusively shown that the same is true of the supposed distinctive character afforded by the conus arteriosus; and it has long been admitted that the spiral valve which has been described in the intestine of *Chirocentrus* is the homologue of that which exists in all the Ganoids, though greatly reduced in *Lepidosteus*. Indeed I am inclined to believe that the circular valve which separates the colon from the rectum in the smelt is merely a last remainder of the spiral valve. Thus, among the supposed absolute distinctions between the Ganoids and the Teleostei, only the peculiarities of the brain, and especially the so-called chiasma of the optic nerves, remain for consideration. My lamented friend Mr. Balfour, in the last of his many valuable labors, proved conclusively that the brain of *Lepidosteus* is, both in structure and development, a Teleostean

* Proceedings Amer. Assoc. Adv. Science, p. 326. Transac. Amer. Philosoph. Soc., p. 449.

† The term ganoid can be used as an adjective to describe the scales already known by that name, and thus be preserved.

‡ Proceedings Zoölogical Society of London, 1883, pp. 137, 138, 139.

brain. But it is singular that no one, so far as I know, has insisted upon the fact, not only that the Teleostean brain is essentially similar to that of the Ganoids, but that it is exactly in those respects in which the Ganoids and Teleostei agree in cerebral structure that they differ most markedly from the Plagiostomi and Chimæroidei.

"With respect to the chiasma of the optic nerves, the exact nature of that structure has not yet been properly elucidated either in the Selachians or in the Ganoids. But, whatever may come of such an investigation, the establishment of the existence of a true chiasma in the Ganoids, and of its absence in Teleosteans, can have but little bearing on the question of their affinities, since Wiedersheim has shown that a simple decussation of the fibres of the optic nerves, as in ordinary Teleosteans, takes place in many lizards."

In 1877* I proposed the following primary divisions of the fishes, and have seen no reason to alter my views as to their value as a correct expression of the affinities and diversities of this class of Vertebrata. The system differs only from that of 1871 in the consolidation of the Crossopterygia and Actinopteri into a single sub-class, the Hyopomata; and in a few corrections of the definitions given. They are as follows:

I. Suspensorium continuous with the cartilaginous cranium, with no hyomandibular. No rudimental opercular bone; no maxillary arch; pelvic bones present; axial series of fore limb shortened, the derivative radii sessile on the basal pieces; axial series of hinder limb prolonged in male.....*Holocephali.*

II. Suspensorium articulated with the cranium; no maxillary arch; no opercular nor pelvic bones; bones of limbs as in the last.....*Elasmobranchi.*

III. Suspensorium rudimental, continuous with cranium, supporting one or more opercular bones; cranium with superior membrane bones; no maxillary arch; a median pelvic element; the limbs supported by segmented unmodified axes.....*Dipnoi.*

IV. Hyomandibular and palatoquadrate bones articulated with cranium, supporting opercular bones; a maxillary arch; no pelvic element; axes of the limbs shortened, the derivative radii sessile on the basal pieces.....*Hyopomata.*

In the definition of the Dipnoi, it is necessary to make the correction in accordance with the best observations on fresh specimens, above referred to, as I have not been able to determine the question from dried specimens in the Hyrtl collection. The suspensorium cannot be properly said to be articulated to the cranium in the sense in which it is said to be such in the Elasmobranchi. In the latter it is articulated by ginglymus; in

* Proceedings of the American Philosophical Society, 1877, p. 25; and in the Annual Reports of the Commissioners of Fisheries of Pennsylvania for 1879–80, p. 67 and 1881–2, p. 111.

the Dipnoi merely by suture or contact, with other cartilage bones. Its character is therefore more nearly that of the Holocephali than of the Elasmobranchi or the Hyopomata.

In the light of the above considerations, to which sub-class must be referred the genus Didymodus? Does it possess a freely articulating hyomandibular bone, and maxillary, palatoquadrate and mandibular arches? The question must be primarily determined by these considerations, since the fins and their supports are unknown to us.

The lateral posterior processes of the skull are in its superior plane, and their extremities do not present an articular facet for the lower jaw. It is improbable that they were continued downwards as cartilage for the former articulation, as in the Holocephali and Dipnoi. Both from the presence of an articular condyle, and from the mechanical necessities of the case, I have little doubt but that there was a freely articulating hyomandibular bone. I have already described this element in fact as visible in a single specimen. The choice is thus limited to the Elasmobranchi and Hyopomata. It is decided in favor of the former by the absence of maxillary arch and of opercular apparatus. So then Didymodus is a shark, in spite of its peculiarities. Kner* speaks of the presence in the nearly allied Pleuracanthus (= Diplodus), of premaxillary and maxillary bones; but this is no doubt a misinterpretation of the homologies, as he says they *articulate with the lower jaw*. In my jaws there is but one bone on each side, a palatopterygoid.

In his researches on the structure of the skulls of sharks, Gegenbaur† shows the different methods of articulation of the palatopterygoid arch in the sub-class Elasmobranchi. In Heterodontus the palatopterygoid arch is attached to the skull throughout by its superior border, anterior to the orbit, but is free posterior to the orbit. In Hexanchus and Heptanchus it is free anteriorly, but articulates by its elevated posterior portion with the postorbital process. In the remainder of known recent Elasmobranchs it is free throughout, and merely in contact in front. These relations are also described by Huxley.‡ Professor Gill utilizes them as definitions of three (of four) primary divisions of the sub-class Elasmobranchi,§ which he names the Opistharthri, (fam. Hexanchidæ); Proarthri (Heterodontidæ); Anarthi (sharks proper); and Rhinæ (Squatinas). According to these definitions, Didymodus must be referred to the Opistharthri. The skull, however, presents other characters which must claim attention. Its

* Sitzungsberichte Wiener Akademie, LV, p. 540.

† Untersuchungen zur Anatomie der Wirbelthiere, Leipzic, 1872.

‡ On the Anatomy of Ceratodus. Proceedings Zoöl. Society of London, 1876, p. 43–4, with figures.

§ Bulletin of the U. S. National Museum, No. 16, 1883, p. 967. Gills fourth group, Rhinæ, does not appear to me to possess the value of the other three, nor are the "Raiæ" and "Pristes" more distinct. I therefore propose that the order Selachii, as defined in the following pages (of the sub-class Elasmobranchi), be divided into three sub-orders: Opistharthri, Proarthri and Anarthri, the latter to include the true sharks, the Squatinæ, the sawfishes and the rays.

reference to the Elasmobranchi is confirmed by the following characters: (1) The nares are not oral. (2) There is a large fontanelle on the summit of the muzzle. (3) There are processes corresponding to the lateral alæ of the basicranial axis.

In another character Didymodus differs from this and all other sub-classes of the Pisces. This is the penetration of the granular ossification throughout the chondrocranium.

In the following characters it agrees with the Dipnoi: (1) The distinct exoccipital, pariëtal, and frontal elements. (2) The occipital cotylus. (3) The posterior bifurcation of the frontal cartilage.

In the following characters Didymodus resembles the Hyopomatous or true fishes: (1) In the basioccipital bone with condyle. (2) In the ?os intercalare or pteroticum. (3) The presence of a distinct element articulating with the proximal end of the hyomandibular. (4) The presence of membrane bones in the position of frontals.

The characters above cited as constituting resemblances to the true fishes, will not, it appears to me, permit the reference of this genus to any of the divisions of sharks established by Prof. Gill. I therefore proposed a new order of the Elasmobranchi* for its reception, with the following name and definition.

A basioccipital bone and condyle. Occipital, ?pterotic, and frontal bones distinct. Supraorbital (or nasal) bones present..... *Ichthyotomi.*

The remaining Elasmobranchi, in which the above characters are wanting, may be termed by way of contrast, utilizing an old name, *Selachii.*

Were it not for the probable presence of the free hyomandibular bone, the order Ichthyotomi might be regarded, in the absence of knowledge of its limbs, as the possible ancestor of the Rhachitomous Batrachia. But as the Batrachia have no distinct suspensorium, or are, to use Müller's convenient term, monimostylic, their origin must still be sought for in some yet undiscovered type of Dipnoi. It is on the other hand very probable that the Ichthyotomi are the group from which the Hyopomata derived their origin. The distinct basioccipital with its two foramina, the superior origin of the hyomandibular, and the superior nostrils, all point towards the true fishes. The tribe of Hyopomata which must be their most immediate descendents, are the Crossopterygia, as I define that division.

I must now compare the Ichthyotomi with such groups of the Hyopomata as they may be supposed to approach most closely. I begin by referring to the marine eels of the order Colocephali. In 1871† I characterized this order as follows: "Pariëtals largely in contact; opercular bones rudimental; the preoperculum generally wanting. Pterygoids rudimental or wanting; ethmoid very wide. Symplectic, maxillary, basal branchihyals, superior and inferior pharyngeal bones, all wanting, except the fourth pharyngeal. This is jaw-like, and is supported by a strong superior branchihyal; other superior branchihyals wanting or cartilaginous."

* American Naturalist, 1884, 413.

† Proceedings American Ass. Adv. Science, xx, pp. 328–334.

The statement "maxillary wanting," is in contradiction to the definition of the sub-class Hyopomata, which asserts the presence of those bones. Stannius* has asserted the absence of the "oberkiefer" in the eel; Günther† describes their presence. As the absence of the maxillary bone would constitute a point of resemblance, if not affinity to the Elasmobranchi, I have reëxamined my material to determine the homologies of the lateral dentigerous bone of the upper jaw of the eels. My specimens of species of the Colocephali include the following from the Hyrtl collection: *Myrus vulgaris; Sphagebranchus rostratus; Moringua rœtaborua; Muræna sp.; Muræna unicolor; Muræna sp.; Poecilophis polyzonus*, and *Gymnomuræna tigrina*. The pterygoid bone exists in a rudimental condition in the *Gymnomuræna tigrina*, *Myrus vulgaris*, and one of the species of Muræna; and whether lost in the preparation of the other crania or not, cannot be stated. In the *Anguilla vulgaris* the pterygoid bone is considerably larger, and extends to a point halfway between its base and the extremity of the muzzle. In the *Conger vulgaris* it extends still further forwards, reaching a transverse process of the anterior part of the vomer. No palatine bone appears. The premaxillary bone is not distinguished from the ethmoid in the Colocephali, nor in the Enchelycephali (Anguillidæ, etc.). It is quite possible, therefore, that the external dentigerous bone or upper jaw, in both of these orders, may be the palatine, and the maxillary be wanting. The family of the Mormyridæ appears to furnish the solution. In this group the structure and connections of the pterygoid bone are much as in Conger, and there are in addition distinct premaxillary and maxillary bones. It is clear that in this family it is the palatine, and not the maxillary bone, that is wanting. Similar evidence is furnished by the family Monopteridæ. The definition of all four of the orders, Colocephali, Enchelycephali, Ichthyocephali and Scyphophori must, therefore, embrace this character. The Gymnarchidæ agrees with the Mormyridæ in this respect, and both families have the transverse process of the vomer which receives the pterygoid, as in the genus Conger.‡ The supposed resemblance to the sharks presented by the Colocephali is then not real, and the question as to the point of affinity of the Ichthyotomi to the true fishes remains open as before.

I now refer to the remarkable characters presented by the deep sea fishes of the family Eurypharyngidæ, as recently published by Messrs. Gill and Ryder.§ These authors find the characters of the skeleton so remarkable, that they think it necessary to establish a new order for its reception, which they call the Lyomeri. The definition which they give is the following: "Fishes with five branchial arches (none modified as branchiostegal or pharyngeal) far behind the skull; an imperfectly ossified skull articulating with the first vertebra by a basioccipital condyle alone; only

* Handbuch der Zootomie, Fische 1854, p. 76.
† Catalogue Fishes, British Museum, vol. viii, p. 19.
‡ These transverse processes are enormously developed in Gymnarchus.
§ Proceedings U. S. National Museum, Nov. 1883, p. 262.

two cephalic arches, both freely movable ; (1) an anterior dentigerous one—the palatine, and (2) the suspensorial, consisting of the hyomandibular and quadrate bones ; without maxillary bones or distinct posterior bony elements to the mandible ; with an imperfect scapular arch remote from the skull ; and with separately ossified but imperfect vertebræ."

M. Vaillant came to no conclusion as to the affinities of this group ; and Messrs. Gill and Ryder remark, "We are unable to appreciate any affinity of Gastrostomus to any Anacanthines, Physostomes, or typical Apods, nor does it seem to be at all related to Malacosteus, which has been universally considered to be a little modified Stomiatid." It is, however, clear to me that the relationships of this family Eurypharyngidæ are to the order Colocephali, and that they represent the extreme degree of the modification of structure which that order exhibits. In other words, the modification of the ordinary piscine type which is found in the Anguillidæ (order Enchelycephali), is carried to a higher degree in the Colocephali, and reaches its extreme in the Eurypharyngidæ. The points of identity between the two groups last-named are so many, that it becomes desirable to ascertain whether they are susceptible of ordinal separation from each other. The characters above given to the order Lyomeri are in fact identical with those which define the order Colocephali, with a few possible exceptions. First, however, I note that the supposed palatine arch, is probably the maxillary, as in the Colocephali, and that it is the palatopterygoid arch which is absent. The five branchial arches exist in the Colocephali, but the three anterior are rudimental, and the basal branchihyal bones of the fourth and fifth are closely united. There are, however, five arches. There is a ceratohyal arch in Muræna and Gymnomuræna, but of very slender proportions. Whether this element is absolutely wanting in Gastrostomus, or whether the first branchial arch is its homologue, remains to be ascertained. Should the last two be coherent as in the Colocephali, we would then have the same number of hyoid arches in both, viz., six. The "imperfectly ossified cranium" is shown in the detailed description given by Messrs. Gill and Ryder, to support the same bones which are found in the Murænoid skull. The degree of ossification of the skeleton does not constitute a basis for ordinal distinction, if the same elements be present. For this reason the perforation of the vertebral centra by the remnant of the chordadorsalis does not seem to be of ordinal importance.

In the more detailed description, there are a few charecters worthy of notice. First, "The notochord is persistent in the skull for half the length of the basioccipital." This indicates further the primitive condition of the vertebral column, but scarcely gives basis for an ordinal definition. Second (p. 266.), "The neurapophyses are slender, diverging (instead of convergent), cartilaginous distally, and embracing the neural sheaths on the sides, while by the neurapophyses is supported a membranous sheath which roofs over the nervous cord," etc. The neural canal is well closed above in the Murænidæ, but in the Anguillidæ it is largely

open above. The neurapophyses it is true unite, but at a distance above the neural cord, and as attenuated rods. Third, "There is no vomer developed, but a triangular cartilaginous element pendent from the cranial rostrum affords attachment for the palatine (read maxillary) element anteriorly," etc. This element probably exists in the Colocephali and similarly takes the place of the vomer, only differing in being ossified. I have been accustomed to regard it as the homologue of the bone called ethmoid in fishes.

The character which distinguishes the Colocephali from the Enchelycephali, now that their maxillary and palatine structure are shown to be essentially the same, is found in the hyoid apparatus. In the Enchelycephali, the structure is as in ordinary fishes; there is a glossohyal, and there are basihyals, and axial branchihyals, and superior pharyngeals. In the Colocephali all these elements are wanting, excepting the fourth superior pharyngeal, which has the form of an antero-posteriorly placed dentigerous jaw, which opposes the lateral branchihyal of the fifth arch or, as it is generally called, the inferior pharyngeal. It is evident that the Eurypharyngidæ are more similar to the Colocephali than to any other order in this respect also, but the description of these parts is not yet sufficiently detailed to enable me to determine what difference there may be in this respect, if any. The mobility of the quadrate bone on the hyomandibular cannot be regarded as of great systematic significance, although it is doubtless important in the economy of the fish.

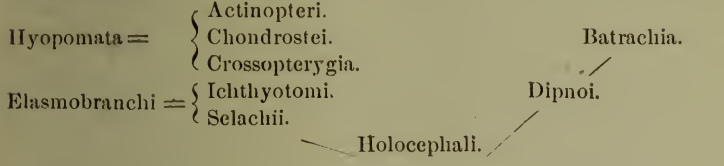
It is then evident that the Eurypharyngidæ belong very near to, if not within, the order Colocephali. Towards the end of their description, Messrs. Gill and Ryder (p. 270), recognize this relationship, but deny that it indicates that this family is "from the same primitive stock as the Murænids." I incline to the belief that it is the ultimate result of the line of development of which the Anguillidæ form one of the first terms, and the Murænidæ a later and more specialized one.

It is therefore clear that the point of relationship of the Ichthyotomi to the true fishes is not to be found in the Eurypharyngidæ or the Colocephali.

In the following point Didymodus resembles Polypterus. The fossa above described as on each side of the basioccipital, is found in Polypterus. There it serves as a place of insertion of a strong ligament on each side, which is attached externally to the epiclavicle, and serves to hold the scapular arch in its place. A similar structure exists in the Siluirdæ, where the ligaments are ossified. It suggests for Didymodus a scapular arch suspended more anteriorly than in sharks, possibly even to the skull.

The genealogy of the fishes will then be as follows, first, however, it is to be understood that in asserting the derivations of one group from another, I mean that in accordance with the rule which I have termed "the doctrine of the unspecialized," the later type in each case is the descendant of the primitive and not the later sub-form of its predecessor. In this way is to be explained the apparent anomaly of regarding the

notochordal sturgeons as descendants of Crossopterygia, whose modern representatives are osseous. The primitive Crossopterygia, and probably even the Actinopteri, were doubtless as cartilaginous as are the existing sturgeons:



In this phylogeny, the Holocephali, which have not differentiated a suspensorium, are regarded as the primitive fishes, although the living representatives display some specialized characters, as, for instance, a membranous gill-cover which conceals the primitive slits. The line to the right continues the monimostylic character and passes into the reptiles, whose primitive types are also monimostylic, as Johannes Müller called them. In the later forms or streptostylicate reptiles of Müller (Lacertilia, Ophidia), the quadrate becomes freely articulated.*

In the left hand series, the Elasmobranchs immediately present us with the free suspensorium or hyomandibular, which is a well-known character of the remainder of the line, the modifications being the additlon of separate elements, as the metapterygoid, "quadrate," and symplectic.

The penetration of ossification into the chondrocranium of Didymodus, in regions not ossified in either fishes or batrachia (sphenoid and presphenoid), and into regions not ossified in any vertebrate (frontal and parietal cartilages), may be, so to speak, only a local phenomenon, and not indicative of extensive phylogenetic consequences. For if it be so regarded, it evidently proves too much, giving affinities in the base of the skull to the reptiles, and in the roof exhibiting a character more highly developed than any known form of vertebrata.

The Ichthyotomi include, so far as yet known, but one family, the Hybodontidæ of Agassiz. According to that author this family includes four genera, Hybodus, Pleuracanthus, Cladodus and Sphenonchus. It ranges from the coal-measures to the Jura inclusive.

The genus Didymodus may be described as follows:

Frontal plane well defined on each side by the temporal fossæ, and terminating in two cornua posteriorly. Anterior nares on the superior surface of the muzzle. Supraorbital (or nasal) bones well separated on the median line and constituting the only membrane ossification Teeth with large lateral denticles.

The species *Didymodus compressus* Newberry, may be defined as follows: Skull with massive walls. Form elongate, depressed, the orbit not ex-

* The phylogeny of the Reptilian series can be found in the Proceedings American Association Advancement of Science, xix, 1871, p. 233. The Batrachia are supposed to be their ancestors.

tending behind the anterior third of the length. Basicranial and basifacial axes in one line, flattened, the supraorbital border flat, concave on the edge; postorbital processes obtuse, the temporal ridges commencing with thin posterior border, which they excavate. The ridges then turn, extend parallel posteriorly, terminating in the horn-like processes already described, with a slight divergence. The apices mark the posterior third of the length of the skull. The occipital condyle is wider than deep, and its superior border retreats forwards so as to cause its cup to look upwards. The exoccipital diameter at the foramen magnum is less than that of the basicranial axis, the osseous element of which, probably sphenoid, is recurved on the sides to their middle. The sides of the latter expand a little to meet their lateral alæ. Immediately above their contact is situated the supposed condyle for the hyomandibular element. The basicranial axis is convex opposite the postorbital processes, from the bases of which a concavity separates it. It has a slight median groove at this point. It is much narrower than the interorbital width above. A short distance in front of the postorbital processes it begins to contract, and gradually reaches an acuminate apex. Superior to this apex, commencing posterior to it, the space between it and the supraorbital or nasal elements is occupied by a massive element (? ethmoid) which forms the floor of the nasal median fontanelle.

The surfaces are smooth, but readily weather so as to be granular. The granules are subround, with flattened surface.

Measurements of skull.	M.
Total length of skull to end of frontal bone (No. 1)....	.180
" " " muzzle to orbit; axial.....	.024
" " " skull to postorbital process.....	.058
" " " " to apices of frontal cartilage.....	.117
" " " " to ? pterotic apex (axial).....	.155
Width of skull at prefontals.....	.045
" " " " supraorbital borders.....	.055
" " " " ? pterotic apices.....	088
" " occipital condyle.....	.034
Depth " " "	.025
Measurements of jaws.	
Length of mandibular ramus from cotylus, inclusive.	.145
Depth " mandibular ramus at cotylus.....	.028
" " " " " middle.....	.035
Length " palatopterygoid bone from cotylus, inclusive.	.145
Depth " " " at postorbital articulation.....	.071
Depth of palatopterygoid bone at orbit.....	.035
Length" " " posterior to orbit	.070

A second species has been brought to light by the researches of Mr. W.

F. Cummins in the Permian beds of Texas. Parts of the jaws with two of its teeth are preserved. The lower jaw is distinguished from that of the *D. compressus* by its small transverse as compared with its other diameters. The ramus is quite compressed, and is not thicker at the inferior edge than the superior, and is slightly concave on the inner side. Its external face is nearly vertical. The angle is rounded forwards, and there is no angle behind the cotylus, which is raised above the superior line of the ramus. The cotylus is rather large, and has a shallow anterior superior, and a posterior subposterior facet. There is no indication of a coronoid process. The inferior edge of the ramus is swollen on the outer side, below the anterior border of the condyle, so as to mark with the thickened posterior edge of the ramus a fossa in the position of the masseteric.

The teeth are pecular in the form of the root (Figs. 8–9). This part has no anterior projection, and the posterior portion is a flat, thin-edged plate, wider than long. It carries a button, but no notch. There is a minute median denticle. The form of the root is thus very different from that of the tooth of the *D. compressus* (figs. 5, 7).

Measurements.	M.
Depth of ramus at cotylus (vertical)	.062
" " " 120 mm. anterior to cotylus.	.048
Transverse diameter at the same point	.009
Long diameter (oblique) of cotylus	.031
Diameters of base of tooth { anteroposterior	.011
Diameters of base of tooth { transverse	.037
Diameters of crown of lateral denticle { anteroposterior	.0048
Diameters of crown of lateral denticle { transverse	.006

I call this species *Didymodus platypternus*. Should the name Didymodus be found hereafter to apply to species of Pleuracanthus, the latter generic name must be used for this species.

III. Historical.

In 1837 Prof. Agassiz (Poiss. foss., iii, 66), described a spine which he believed to have belonged to a fish like the sting-rays, as *Pleuracanthus lævissimus*. The only example was obtained from the Dudley Coal field.

In 1845 Prof. Agassiz (Poiss. foss., iii, 204), made known certain teeth, which he referred to sharks of the family of Hybodonts. Two species were distinguished, *D. gibbossus* and *D. minutus*. Both were obtained from the English Coal measures.

In 1848 Prof. Beyrich (Berichte vernandl. k. Preuss. Akad. wiss., 1848), proposed the generic name Xenacanthus for a German Carboniferous form, referred to Orthacanthus by Goldfuss (1847), but which approached nearer to Pleuracanthus.

In 1849 Dr. Jordan (Jahrbuch für Min. u. Geol., p. 843), described, under the name *Triodus sessilis*, a form subsequently ascertained to be identical with the Xenacanthus.

In 1857 Sir Philip de Malpas Gray Egerton (Ann. and Mag. Nat. Hist., xx, 423), contended that the spines of Pleuracanthus belonged to the same fish as the Diplodus teeth, and that Xenacanthus was likewise referable to the same type.

In 1867 Prof. Kner (Sitzb. k. Akad. wiss. Wien, lv, 540–584), published a memoir, illustrated by ten plates, in which he proved that Diplodus and Xenacanthus were generically identical.

In 1875 Messrs. St. John and Worthen proposed the genus Thrinacodus for the *Diplodus incurvus* and *D. duplicatus* of Newberry and Worthen and the *T. nanus* St. J. and W., from Illinois.

In 1883, in the Proceedings of the Philadelphia Academy (p. 108), I proposed the name Didymodus for the *Diplodus compressus* Newberry.

In Science for 1884, p. 274 (March 7th), I called attention to the close resemblance of the teeth of this genus to those of the recent shark, called by Garman Chlamydoselachus, and expressed my belief in the identity of the two genera.

In the American Naturalist for April, 1884, p. 413, I gave a brief abstract of the characters of the skull of Didymodus, and proposed to regard it as the type of a new order to be called the Ichthyotomi.

In Science, 1884, p. 429 (April 11), Prof. Gill objects to the identification of the genera Didymodus and Chlamydoselachus; on the ground of the different forms of the teeth. He states that he doubts the pertinence of the two genera to the same order. He points out that the oldest name for Diplodus Ag. is Pleuracanthus Ag., and that the order Ichthyotomi had been already defined and named by Lütken, with the name Xenacanthini.

On these various propositions the following remarks may be made.

(1.) There is no generic difference to be detected, in my opinion, between the teeth which are typical of Diplodus Agass. and Thrinacodus St. J. and W. and the recent Chlamydoselachus. Differences there are, but apparently not of generic value. The identification of the recent and extinct genera rests, as far as this point goes, on the same basis as that of the recent and extinct Ceratodus.

(2.) At the time of my proposal of the name Didymodus, I was not convinced that fishes of this type bore the spines referred to the genus Pleuracanthus Ag. None of the authors cited figure any specimens which present both tricuspidate teeth and a nuchal spine. None of my ten specimens possess a spine. However, Kner describes two specimens as exhibiting both tricuspidate teeth and a spine, and Sir P. Egerton's statements (*l. c.*), on this point are positive. So we must regard Pleuracanthus as the name of this genus, with Diplodus as a synonym.

(?.) Diplodus being regarded as a synomym of Pleuracanthus, it follows that Chlamydoselachus Garm. is distinct, on account of the *different structure of the dorsal fin*, which is single and elongate in Pleuracanthus, according to Geinitz and Kner. The presence of the nuchal spine in Pleuracanthus is also probably a character of distinction, although we do not yet know whether such a spine is concealed in Chlamydoselachus or not.

(4.) The identity of Didymodus (type *Diplodus compressus* Newberry) and Pleuracanthus, may now be questioned. None of the specimens are figured and described by the authors above cited, as displaying an occi pital condyle, or posterior frontal cornua. My specimens of *Didymodus compressus* do not exhibit teeth on the roof of the mouth, as Kner describes. There are no spines with the crania, although separate Pleuracanthus spines are not rare in the same beds. The teeth associated with the skulls, moreover, present a button on the superior side of the root (Fig. 5). Agassiz figures teeth of this kind as belonging to the *Diplodus gibbosus*. St. John and Worthen make these teeth typical of Diplodus, and confer the name Thrinacodus on those without the button, a character which I do not think a constant one. The latter name is then probably a synonym of Pleuracanthus. The button-bearing teeth are figured and described by Kner as occurring scattered, and in a somewhat different horizon from that of the Pleuracanthus specimens. In Germany, as in Texas, the button-bearing teeth are the larger. I suspect that the skull I have described represents a different genus from Pleuracanthus proper. This genus will not differ from Chlamydoselachus Garm., in the lack of other evidence; the teeth presenting only specific difference.

(5.) Of course, a study of the anatomy of Chlamydoselachus, which I hope Mr. Garman will soon give us, may reveal differences between that genus and *Didymodus;* but of these we know nothing as yet.

(6.) The order Xenacanthini was proposed by Geinitz (Dyas) for Pleuracanthus, on account of the supposed suctorial character of the ventral fins. This character is supposed by Kner to be sexual. In any case this division, whatever its value, must be subordinated to the order Ichthyotomi, as I define it.

EXPLANATION OF PLATE.

All the figures two-thirds natural size, except fig. 6, which is one-half larger than nature.

Fig. 1. Skull from above, right frontal bone displaced, and its anterior extremity broken off. Posterior apex broken from right frontal cartilage bone. *a*, Frontal or supraorbital bone, that of the right side displaced; *b*, anterior nostril; *c*, postfrontal facet for palatopterygoid; *d*, frontal fissure.

Fig. 2. Posterior part of skull of another individual, from above; *a*, occipital bone; *b*, pariëtal; *c*, a cornua of frontal bone.

Fig. 3. Anterior view of fig. 2, displaying section of brain case; *a*, frontal or pariëtal cartilage bone; *b*, sphenoid; *c*, brain cavity; *d*, frontopariëtal fontanelle; *e*, hyomandibular condyle (? pterotic bone).

Fig. 4. Anterior part of skull from below, of a third individual, displaying orbits and postorbital processes.

Fig 5. Tooth of *Didymodus compressus* Newb., natural size, posterior view.

Fig. 6. Palatopterygoid and mandibular arches of a fourth individual from right side, with *hm*, hyomandibular.

Fig. 7. Superior tooth of external row, without apices of two of the cusps ; from the palatine bone of the specimen represented in fig. 5 ; one-half larger than nature, anterior view.

Fig. 8. Tooth of *Didymodus platypternus* Cope, nat. size, from above posteriorly.

Fig. 9. Tooth of a second specimen of *Didymodus platypternus* from below.

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THE EXTINCT MAMMALIA

OF THE

VALLEY OF MEXICO.

Read before the American Philosophical Society, May 16, 1884.

ON THE

STRUCTURE OF THE FEET IN THE EXTINCT ARTIODACTYLA OF NORTH AMERICA.

Read before the American Philosophical Society, Aug. 15, 1884.

FIFTH CONTRIBUTION TO THE

Knowledge of the Fauna of the Permian Formation

OF

TEXAS AND THE INDIAN TERRITORY.

Read before the American Philosophical Society, Aug. 15, 1884.

By Professor E. D. Cope.

FOR SALE BY A. E. FOOTE,
1223 BELMONT AVENUE,
PHILADELPHIA.

The Extinct Mammalia of the Valley of Mexico. By E. D. Cope.

(*Read before the American Philosophical Society, May 16, 1884.*)

The following study is based primarily on an examination of the specimens contained in the Museum Nacional of Mexico, which I was permitted to make through the kindness of the Director of the Departments of Geology and Mineralogy, Professor Mariano Barcena. Through the mediation of the same gentleman, I obtained permission from Professor Antonio Castillo, Director of the School of Mines, to examine the corresponding material preserved in the fine museum of that institution. The knowledge derived from the study of the latter, reinforced the results I obtained from the study of the specimens of the Museum Nacional, so as to enable me to reach definite conclusions as to the definitions of various species which are represented in both collections. I wish to record the obligations under which I have been laid by both of these distinguished gentlemen. I have, through their aid, been enabled to make a comparison between the pliocene fauna of Mexico, and that of Buenos Ayres, and that of Oregon. The species of the Pampean fauna contained in my private collection, are those exhibited by Messrs. Ameghino, Larroque and Brachet, at the Exposition of Paris of 1878. My Oregon material is derived from the explorations of my parties under Messrs. Sternberg and Duncan, and those of Professor Thomas Condon of the University of Oregon, who kindly lent me his collection.

The collections of the museums of the City of Mexico, above mentioned, are derived from the locality Tequixquiac, and the specimens referred to in the following pages are to be understood as having been derived from that locality unless otherwise stated. Tequixquiac is situated on the northern edge of the valley of Mexico, north of the City of Mexico and the town of Zimpango, and east of the gorge of Nochistongo.

GLYPTODON Owen.

GLYPTODON, sp. indet.

A nearly complete carapace of this remarkable animal is mounted in the Museum Nacional, and a second, nearly as well preserved, is in the Museum of the School of Mines. Jaws and teeth occur in the latter museum. The discovery of this genus at this extreme northern locality is due to Dr. Antonio Castillo. It was first announced by Dr. Mariano Barcena in the Revista Cientifica of Mexico, 1882, I, p. 3. The extension of this far southern genus to the latitude of Mexico during the Pliocene (Pampean) epoch, is entirely consistent with the further distribution of the great sloths and llamas to the United States at the same time.

DIBELODON Cope.

Mastodon pars, auctorum.

Various attempts have been made to define as genera groups of species which are included within the limits of the genus Mastodon of authors. The first new name, Tetracaulodon, was introduced by Dr. Godman, who saw in the mandibular tusks of some individuals of the *Mastodon americanus* Cuv., ground of its separation from the genus Mastodon, in which he believed those teeth to be wanting. This division was adopted by Dr. Grant and others, but has not been generally allowed. The next division was that proposed by Dr. Falconer, who, however, did not employ the names proposed by him in more than a subgeneric sense. He distinguished two series in the genus Mastodon. In one of these, the P-m. 3, and the Ms. 1 and 2 present three transverse crests, while in the other division these teeth present four such crests. To these divisions he gave the names of Trilophodon and Tetralophodon respectively. The third attempt at division is that of Herr Vacek, who gives names to the two divisions of the genus in which the cross-crests are composed of tubercles or continuous ridges. These divisions he calls Bunolophodon and Zygolophodon respectively.*

I will refer to these divisions in reversed order. Those proposed by Vacek cannot be regarded as genera, and their author did not use them as such. The tubercular crest passes into the straight crest by insensible stages. The divisions proposed by Falconer are more distinct, but not sufficiently so to represent genera. This may be understood by reference to the second lower molar of the *Mastodon augustidens*, which is, in some individuals, three crested, and in others four crested. Some other species present the same difficulty. On this point I quote the remarks of Dr. Lydekker :† "The foregoing survey of such a large series of Mastodon molars has led to the conclusion that the very regular ridge formula given by Falconer will not always hold good in regard to the true molars,

* Vacek, Ueber Oesterreichische Mastodonten. Abh. der K. K. Geolog. Reichanstalt, vii, Heft iv, Wien, 1877, p. 45.

† Geological Survey of India, Series x, Vol. i, pt. v, 1880, p. 256.

though in the Indian species, at all events, it appears to be always constant in the milk-molars. We have seen that there is a tendency in the true molars of some of the Trilophodons (*M. falconeri*) to develop the talon into a fourth ridge, and in the Tetralophodons (*M. latidens* and *M. sivalensis*), a similar talon is developed into a fifth ridge, in the intermediate true molars." *M. humboldtii* Cuv. (*M. andium* Falc.*) shows a small fourth crest on the second true molar, according to Falconer.†

The lower incisor teeth, on which Godman relied for the definition of his genus Tetracaulodon, were shown by Harlan, not to be constantly present in the *Mastodon americanus*. In fact, no adult specimen has been described in which two inferior incisors are present. The single one observed is very rarely found in adults, being a character more frequently found in the young. It is in this species a remnant of a character elsewhere constant, which does not disappear quite so soon as the teeth of the whalebone whale, and superior incisors of the ruminant. But it is otherwise with other species referred to Mastodon. No specimens of the *Mastodontes angustidens, productus* and *longirostris*, are recorded, in which two inferior incisors are not present. For this reason the first and last-named were placed by Grant and others in the genus Tetracaulodon. Unfortunately this name was applied by its author to the *M. americanus* only, a species which cannot enter the genus furnished with a pair of persistent inferior incisors. It is also the type of Cuvier's Mastodon.‡ It thus unavoidably becomes a synonym of the latter.

There is no doubt that the presence of a pair of persistent inferior incisors defines a genus as distinct from one in which there is not a pair of permanent inferior incisors. I agree, therefore, with Grant and others, in separating the Mastodons which present this character from the genus Mastodon, under another generic head. I believe, also, that the presence or absence of a band of enamel on the superior incisors furnishes ground for the recognition of distinct generic groups, and would be so used in any other division of the Mammalia. It is often asked why it is necessary to multiply generic names on such grounds. My answer is simply an expression of the law governing the case, based on the supposition that when the species of animals and plants come to be fully known, the genetic series will be found to be uninterrupted, excepting by the presence or absence of characters which appear or disappear during the growth of a set of individuals, which we on this account call a species, or refer to a genus. The difference in the two cases consists in this: In the case of species, the characters are numerous and are matters of proportion, size, color, texture, etc., while in the case of the genus the character is single, and marks one step in the serial chain of structural modifications. In the case of the genus there is an actual addition or subtraction of some distinct

* Palæontological Memoirs of Falconer, i, p. 100, pl. 8.

† Loc. cit., ii, p. 15.

‡ Ossemens Fossiles, ii, p. 252, Ed. 1834: "Ann. Mus., 1806, viii, 272," teste Leidy.

part or piece of the organism.* If now we fail to notice these points or steps, we must abolish all genera. If we define some and fail to define others, our practice ceases to have the uniformity of a law, and we abandon the basis of scientific order.† One point, however, must be insisted on. In order that a character be usable for any purpose of definition, it *must define*. That is, it must belong to all the individuals referred to the species, genus, etc., defined, and must not be present in some individuals and wanting in others of those supposed to be defined by it. This being the case, adult animals only can be used for definition, as characters, especially generic, are added from time to time up to maturity. Sometimes only one sex can be considered, since the adult characters are in certain cases never reached by one sex or the other. This is often the case with insects. Moreover, some latitude for exceptional variations must be allowed. Thus, the exceptional absence of the last molar in a dog does not invalidate the definition of the genus Canis, M. $\frac{2}{3}$.

Of course, if all specimens of animals could be found, the definitions would all, or nearly all, be invalidated. But it is safe to assume that all the intermediate forms will not be found, so that the definitions of species will represent the state of our knowledge, and the results of the operations of nature in the preservation of individuals.

The case is somewhat different with regard to generic characters. As these involve the addition or subtraction of some part, having definite dimensions, it is quite possible to say when the latter is present or absent. Characters of this kind present the appearance of abruptness of transition, to which I have referred in my paper "On the Origin of Genera," and which gave rise to the formulation, by Professor Hyatt and myself, of the "laws of acceleration and retardation." When such change prevails throughout all the individuals of one or more species, a new genus has its origin. As a matter of fact, the creation of generic modifications has been exhibited, in the history of life, by many individuals nearly contemporaneously. As the change involves *but one character*, it offers a better opportunity for the formulization of the laws of evolution, than in the case of specific characters, which are more numerous.

The three genera of Elephantidæ, of which mention has been made above, will then be defined as follows:

Mastodon Cuv. Superior incisors without enamel band; inferior incisors wanting. Type *M. americanus.*

Dibelodon Cope. Superior incisors with enamel band; inferior incisors wanting. Type *D. shepardi.*

Tetrabelodon Cope. Superior incisors with enamel band; inferior incisors present in the male at least. Type *T. angustidens.*

To the genus Mastodon must be referred the following species. For

* See "Origin of Genera," Proc. Acad. Philada., 1869, where this point is discussed.

† American Naturalist, 1884, July, p.

the dental characters of the Indian species I am indebted to Messrs. Falconer and Lydekker :

Mastodon americanus Cuv., N. America.
" *?borsoni* Hays, E. and S. Europe.
" *mirificus* Leidy, N. America.
" *falconeri* Lydd., India.
" *arvernensis* C. & J., Europe.
" *sivalensis* Falc., India.
" *latidens* Clift., India.
Dibelodon shepardi Leidy, California, Mexico.
" *tropicus* Cope, Tropical America.
" *humboldtii* Cuv., South America.
Tetrabelodon angustidens Cuv., India, Europe, N. America.
" *andium* Cuv., S. America, Mexico.
" *productus* Cope, SW. N. America.
" *euhypodon** Cope, N. America.
" *pentelici* Gaudry, SE. Europe.
" *perimensis* Falc., India.
" *pandionis* Falc., India.
" *turicensis*† Schinz, Europe.
" *campester* Cope, N. America.
" *longirostris* Kaup, Europe.

The condition of the inferior incisors is unknown in the *Mastodon atticus* Wagner, and *M. serridens* Cope, and *M. proavus* Cope ; and in some of the above species the presence of an enamel band on the superior incisors has not been established.

I may add that I do not perceive how the so-called genus Stegodon can be distinguished, as at present, by the number of crests of the intermediate molars, and by the presence of cementum. It will probably be necessary to look for other characters in order to sustain it.

DIBELODON SHEPARDI Leidy.

Mastodon shepardi Leidy, Proceedings Academy Philadelphia, 1870, p. 98 ; 1872, p. 142.

Mastodon obscurus Leidy part, Report U. S. Geol. Survey Terrs. I, p. 330, Plate xxi.

This species was originally proposed on the evidence of a last inferior molar tooth from Contra Costa county, California, and a part of a superior tusk from Stanislaus county in the same State. Dr. Leidy subsequently abandoned the species. I however revived it in a synoptic table of the species of North American Mastodons in 1884. ‡

The fossils of the Museum Nacional of Mexico, examined by me, included

* American Naturalist, 1884, p. 525.

† Von Meyer is my authority for the presence of mandibular tusks in this species, = *M. virgatidens* Meyer.

‡ American Naturalist, 1884, p. 524.

a well-preserved lower jaw of a Mastodon, which presents both rami, and both the last true molars, and the entire symphysis. In the collection of the Ecole des Mines I saw a palate with the second and third true molars of both sides in place, and the superior incisor teeth, or tusks. Other fragments of jaws, with numerous isolated molars, were seen in these collections and in that of the college of the city of Toluca.*

From these specimens it is clear that the high valleys of Mexico were inhabited by a trilophodont mastodon, with a short decurved toothless symphysis like that of the *Elephas primigenius*, and with a band of enamel on the superior incisor tusks. The molars have the characters of those of the *Mastodon andium* of authors, and are of about the same size. The cross-crests are divided at the middle line only, and one half wears into a trefoil, while the other half wears into an oval, transverse to the long axis of the crown. The unworn crests are obtuse and not serrate; and there are no accessory tubercles besides those forming the lateral lobes of the trefoils. The size of the ramus and of the teeth is about that of the *M. angustidens*, and smaller than that of the *M. humboldtii*. The last inferior and last superior molars have but four cross-crests and a small heel. This I verified on several specimens.

A comparison of this species with those described, yields the following results: In the character of its molars it is identical with the *M. andium*, and differs from the *M. humboldtii* in the characters which distinguish the two species, as pointed out by Gervais.† That is, only one-half of each cross-crest wears into a trefoil, and the size is inferior. But it cannot be identified with the *Tetrabelodon andium*, because, according to Falconer,‡ that species possesses a long massive deflected beak containing an incisor tooth.‖ It is true that the specimen figured by Laurillard in D'Orbigny's voyage dans l'Amerique Meridionale, Pl. x, does not display a long beak and tusk, although the symphysis is much more pronounced than in the present species. But that plate is made from a drawing, and may thus be of doubtful authority. If correct, it may represent the female, or, as Falconer suggests, the young of the *T. andium*. The last inferior molar figured by Dr. Leidy, l. c., and formerly referred to a species under the name of *Mastodon shepardi*, has the character of the corresponding tooth of the Mexican species under consideration. The plate does not, however, represent the specimen satisfactorily in one respect. The trefoils are not sufficiently distinct, on account of the faint representation of their basal lobes. These nearly block up the cross valley, a fact not to be derived from an examination of the plate, but which is clearly seen in a cast preserved in the museum of the Philadelphia Academy of Natural Sciences.

* For the opportunity of examining the museum of this Institution I am much indebted to its President, Dr. Villada.

† In Castelnau's Expedition, 1855; Recherches sur les Mammiferes Fossiles de l'Amerique Meridionale, p. 14.

‡ Palæontological Memoirs, ii, pp. 226, 274.

‖ The lower jaw figured by Falconer, Mem. i. p. 100, from Buenos Ayres, as *M. audium* is clearly *M. humboldtii*.

This specimen also agrees with those in the Mexican museums in the small number of crests on the last inferior molar : four with a short rudimental heel. Another specimen of apparently the same species is described and figured by Leidy as having been brought from Tambla, Honduras.* This tooth is apparently anomalous in the contraction of the third cross-crest.

The range of this species may then be given as extending from California to the valley of Mexico, inclusive.

A species apparently allied to the *Dibelodon shepardi* is the *Mastodon serridens* Cope,† of which the typical specimen was brought from south-western Texas. Premolar teeth of the same type were shown me by Professor Castillo, in the museum of the School of Mines. These came from a lignitic bed at Tehuichila, in the State of Morelos, of Loup Fork age. This epoch is indicated by the presence of the genera Protohippus and Hippotherium. The sharp, serrate edges of the crests distinguish the molar teeth from those of the *D. shepardi*, and as the species probably came from different horizons, they are probably distinct. A premolar mingled with those of *D. shepardi*, from the valley of Toluca, much resembles that of the *M. serridens*.

Dibelodon tropicus Cope, sp. nov.

Mastodon humboldtii? VonMeyer Palæontographica, 1867, Studien ueber das genus Mastodon, p. 64, Pl. vi. *Mastodon andium* Leidy, Proceedings Academy Philada., 1876, p. 38.

A second species of Dibelodon inhabited the valley of Mexico, of larger size than the *D. shepardi*, and differing somewhat in the dentition. Von Meyer describes and figures a ramus of a lower jaw, l. c., brought by Herr Uhde from Mexico, which has, according to Von Meyer, no mandibular tusk, and probably a short elephantine symphysis. A very similar ramus, containing the last molar tooth, was presented to the Philadelphia Academy of Natural Sciences by Dr. Isaac Coates, who obtained it from Tarrapota, on the Huallaga river, in Eastern Peru. The extremity of the symphysis of this specimen is broken away, but enough remains to show that it was probably short, and that there was no inferior incisor.

Reference to Von Meyer's figure shows that the last inferior molar has five well-developed cross-crests and a heel. The Peruvian specimen has the same character, the fifth cross-crest a very little more contracted than in Von Meyer's plate. Dr. Leidy describes the specimen as having four transverse ridges, besides a strong tubercular talon. But it seems to me that the talon is of such size as to be properly included in the cross-crests. On the same principle one might say that the *D. shepardi* has three cross-crests and a strong talon, as it has one less cross-crest than the *D. tropicus*. The additional cross-crest, and the superior size, distinguish this form as a species from the *D. shepardi*. Von Meyer perceived these differences, and referred his specimen to the *D. humboldtii*. I am fortunately able to

* Extinct Mammalia Dakota and Nebraska, Pl. xxvii, fig. 14.

† American Naturalist, 1884, p. 524.

make a comparison of his plate and the Peruvian jaw, with a well preserved jaw of the *D. humboldtii*, with perfect last molar and symphysis, from Buenos Ayres, in my collection. I am able fully to substantiate the characters already pointed out by Gervais, and to prove that the cross-crests of the molars form double trefoils, while those of the *D. tropicus* are like those of *D. shepardi* and the *Tetrabelodon andium*.

The species last named is said by Falconer (loc. sup. cit.) to occur in Mexico, and speaks of having seen a well preserved lower jaw from the State of Tlaxcala. I have not met with it.

The *Mastodon americanus* has not yet been found in Mexico. The most southern localities for the species known to me are Southern California, and near San Antonio, Texas. From the former region I possess a ramus with the last molar, presented to me by Mr. Scupham, of San Francisco; the other specimen was obtained from Mr. G. W. Marnock, of Helotes, near San Antonio, Texas.

ELEPHAS Linn.

ELEPHAS PRIMIGENIUS Blum.

This species, of both the thick and thin plated varieties, was once very abundant in Mexico. I have received a series of teeth from Candela, in the State of Coahuila, from Dr. Caspar Butcher, through my friend Dr. Persifor Frazer; and Von Meyer has pointed out the occurrence of its remains in the valley of Mexico. The museums of Mexico contain very numerous portions of skeletons of this species, which prove that it was far more abundant than the species of Mastodon. Up to this time this locality is the southern known limit of its distribution on the American continent.

APHELOPS Cope.

APHELOPS, sp. *Aphelops ?fossiger* Cope. Proceedings Academy Philadelphia, 1883, p. 301.

The right half of the mandible, with part of the symphysis of a rhinoceros, was found in the valley of Toluca, sixty miles west from the city of Mexico, and Dr. Barcena sent me a photograph of it a year ago. I published a notice of it as above cited, in connection with remarks on a rhinoceros skull which I obtained on one of the heads of the Gila river in New Mexico. On my recent visit to the College of Toluca, I had, through the kindness of Professor Viilada, the opportunity of examining the jaw. Its characters do not differ much from those of the *Aphelops fossiger* Cope. It is considerably smaller, and has a very short diastema, but not shorter than in some jaws of the *A. fossiger*. The dimensions are as follows:

Measurements.	M.
Length of ramus from base of canine	.400
" " dental series with canine, less M. iii	.235
" " molar series, less M. iii	.200
" " true molars, less M. iii	.105

Measurements.	M.
Diameter of canine (transverse)	.027
" of P-m. ii	.007
Depth of ramus at P-m. iii	.070
" " " at M. i	.085
" " " at front of M. iii	.090

The matrix in which this jaw was found, is much like the Upper Pliocene material of Tequixquiac. It is therefore of probably later age than the true *Aphelops fossiger*, which is a characteristic Loup Fork species. Leidy describes (Extinct Fauna of Dakota and Nebraska, p. 230) a rhinocerus, probably an Aphelops, from California, under the name of *R. hesperius*. It is smaller than the Toluca specimen, but has a considerably longer diastema. Its geological horizon is uncertain.

I mention here that rhinoceroses, probably of the genus Aphelops, apparently existed in North America during the Pliocene period. Bones of a species having resemblances to the *A. fossiger* have been sent me by my assistant, George C. Duncan, from the Equus beds of the eastern part of the Oregon desert. The genus has been hitherto supposed not to ascend higher than the Loup Fork, or Upper Miocene beds. These bones are accompanied by teeth of a peculiar Hippotherium unlike those of any species of the genus known to me from the Loup Fork Miocene.

EQUUS Linn.

The remains of horses are very abundant in the valley of Mexico,* and represent four species. In the determination of these species it has become necessary to compare them with those hitherto found in North and South America. In making this comparison I exclude the species of Hippidium, which are all American, and whose molar teeth are easily distinguished by the equality in size of the internal columns; resembling in this respect the genus Protohippus.

When the species of the genus Equus differ in the characters of their superior molar teeth, the diversity is to be seen in the size and form of the anterior internal column. The anteroposterior diameter of this column, as well as the integrity or emargination of the internal border of its section, varies according to the species. The infolding or the borders of the lakes has a value, but a less constant one. The *Equus caballus* differs from all of the American extinct species, where the corresponding parts are preserved, in the great elongation of the face, which is expressed in the greater lengths of the diastemata anterior and posterior to the canine tooth in both jaws. Other characters may be observed in the relative lengths of the limb bones, the form of the occiput, etc. It has been shown by Leidy, Rütimeyer and others, that it is not always practicable to distinguish the species of horses by their teeth alone. A glance at Owen's

* This fact has already been made known by Von Meyer, Palæontographica, 1867, p. 70, and Owen, Transactions of the Royal Society, London, 1869.

plates of the dentition of the existing species of Equus*, shows the truth of this statement. Among the extinct species of Equus the range of variation is greater.

The following attempt at a discrimination of the species known to me, or so fully described as to be well known, must necessarily be regarded as provisional, until the skeletons are more fully recovered. American extinct species only are introduced :

I. Long diameter of anterior internal lobe of superior molars not greater than one third the long diameter of the crown.

Borders of lakes crenate ; internal anterior lobe notched on the inner side so as to be bilobate ; crowns a little curved ; large.....*E. crenidens.*

II. Long diameter of anterior internal lobe more than one-third and not more than one-half the anteroposterior diameter of the crown.

α Crowns more or less curved.

Crowns wider than, or as wide as long ; enamel edges little folded.....*E. curvidens.*

$\alpha\alpha$ Crowns straight or nearly so.

β Diastemata longer.

Crowns nearly square, enamel not very complex ; no facial fossa ; maxillary bone produced much beyond M. iii.....*E. caballus.*

$\beta\beta$ Diastemata shorter.

γ No facial fossa.

Crowns nearly square ; enamel not very complex ; maxillary bone little produced behind last molar ; smaller.....*E. hemionus ; E. burchelli ; E. quagga ; E. zebra ; E. asinus.*

Crowns longer than wide on face ; enamel little complicated ; face and maxillary unknown ; large.....*E. occidentalis.*

Crowns square ; enamel more folded than in other species ; face and maxillary unknown ; large.....*E. major.*

γ A facial fossa.

Crowns nearly square ; enamel less complex ; maxillary short posteriorly ; smaller.....*E. andium.*

III. Long diameter of anterior inner lobe more than half that of crown of molar teeth.

Crowns square ; enamel little complex (in Mexican specimens) ; diastemata and maxillary behind shorter ; no facial fossa ; large...*E. excelsus.*

Crowns square ; enamel little complex ; smallest species.....*E. barcenæi.*

In using the above table it must be noted that gradations in the diameter of the anterior internal column (or lobe) exist, not only between individuals of the same species, but between different teeth in the same jaw. This diameter is always greatest in the last superior molar, and the characters of this tooth are such that they cannot be used in connection with the above table.

* Philosophical Transactions, 1869.

Before describing the Mexican species I make some notes on the others embraced in the above list :

Equus curvidens Owen. Of eight superior molar teeth from Buenos Ayres in my collection, two second premolars are perfectly straight, while the third true molar is the most curved. The other teeth exhibit different degrees of curvature. The area of the anterior internal column is not so flat on the inner side in any of them as in Owen's Plate (Voyage of the *Beagle*, Vol. i). My teeth have also a rather greater transverse diameter than Professor Owen's type.

Equus caballus L. The common horse differs from all of the extinct species of the genus from American localities where the muzzle is known, in the greater length of the latter, with its diastemata, of both jaws, and in the greater prolongation of the maxillary bone posterior to the last true molar. Appropriately to the anterior position of the molar series, the facial ridge commences above the middle of the first true molar. In an *Equus quagga* in my possession the ridge commences above the middle of the last premolar. The basioccipital bone is more compressed than in any species of the genus known to me.

Equus occidentalis Leidy. This species is represented in my collections by at least one hundred individuals, some of which have been lent me by my friend Professor Thomas Condon of the University of Oregon. They are nearly all derived from the Equus beds of the Oregon desert. Unfortunately there is no perfect skull. A few specimens from the same region I refer to the *Equus excelsus*, but as these are comparatively rare, I am safe in referring most of the bones to the other species. In these I find the following characters to separate the species from the *Equus caballus* : (1) The basioccipital bone is not compressed, and besides its inferior lateral angles it has a pair of lateral angles, one proceeding forwards from the inferior border of each *foramen condyloideum anterius*. (2) The fossa enclosed between the paroccipital process and the basioccipital, is deeper, and has a raised border in front which separates it strongly from the plane of the petrous bone. This is not found in *E. caballus*. I verify it in three separate occipital bones of the *E. occidentalis*. (3) The astragalus and other bones of the feet are smaller than in *E. caballus ;* the first named intermediate in size between that of the horse and that of the quagga. The cannon bones, when of the same length, are more slender. (4) The inferior canine issues in direct contact with the last incisor, without the diastema seen in the horse ; and the incisive arc is narrower and more produced. The symphysis is elongated not only forwards, but also posteriorly. The mental foramen is anterior to the bifurcation of the rami in *E. occidentalis*, posterior to it in *E. caballus*.

Equus major Dekay. Dr. Leidy leads us to infer (Report U. S. Geol. Survey Terrs., Vol. i, p. 244), that this species differs from the *E. occidentalis*, in the generally greater complication of the enamel folds. This I find to be the case in specimens from the Fish House, in the brick clay, near Philadelphia, and from the Big Bone Lick, Kentucky. Leidy

figures similar specimens from various parts of the Eastern and Southern States.

EQUUS CRENIDENS Cope, sp. nov.

This large species of true horse is represented by molar teeth and fragments of jaws belonging to two individuals preserved in the Museo Nacional of Mexico, and to two others preserved in the Escuela des Minas. The typical specimen includes the three premolars of the upper jaw of an adult in perfect preservation.

The species is primarily distinguished by the close and strong wrinkling of the enamel border of the lakes of the superior molar teeth. This wrinkling, or vertical plication, reminds one of what is seen in the *Elephas indicus*. This wrinkling is not found in the enamel edges which border the interior crescents on the inner side, nor in those bordering the internal lobes or columns. The borders of the lakes are not folded in the complex loops seen in *Equus major* Dek., but have the plainer looping seen in the *Equus tau* Ow. The grinding faces are nearly square. That of the second premolar is a rather shortened triangle, and less produced anteriorly than in the *E. tau*. The crowns of the third and fourth premolars are long and slightly curved.

The measurements show that this is one of the larger species of horse.

Measurements.		M.
Diameters of P-m. ii	anteroposterior	.0430
	transverse	.0305
Diameters of P-m. iii	anteroposterior	.0335
	transverse	.0340
Diameters of P-m. iv	anteroposterior	.0310
	transverse	.0350

The crimping of the enamel of the lakes distinguishes this species from the others of the genus.

From Tequixquiac.

EQUUS TAU Owen. Philosophical Transactions of the Royal Society, 1869; p. 565; pl. lxi; fig. 4.

Of this species there are preserved in the Museum Nacional five superior molars, some of which belong apparently to one individual. In the Escuela des Minas, the series is a fine one. There are two skulls lacking the occiput; one skull lacking the occiput and muzzle; parts of both maxillary bones with teeth, of one skull; and a single maxillary bone with teeth, of a fifth skull. The specimen mentioned under the second head, has teeth and palate preserved, as in the figure given by Owen of his *Equus conversidens*, and I suspect it was from this specimen that the photograph was taken from which Professor Owen's figure and plate were made. It is possible that his figure and description of the *Equus tau* were made from one of the maxillary bones mentioned under head three. I am not able to perceive the specific differences between these specimens. The character displayed

by Owen's *E. conversidens*, on which he relied to distinguish the species, may be the result of distortion. The maxillary bones of the type are loose and may be made to assume different angles to each other. The last superior molar is represented as unusually short by Owen. This appearance could be produced by the oblique angle of the aperture of the camera in photographing, due to its too anterior position. Be that as it may, I could detect no specific differences between the seven or eight specimens I examined.

The *Equus tau* is an average horse in all respects, presenting no very tangible characters by which to distinguish it from the existing species of the *E. asinus* and *E. zebra* group, so far as the parts which I examined go. It has the internal anterior column of the superior molar always less in diameter than half that of the crown of the tooth, and not characterized by any marked peculiarity. The borders of the lakes have an entering loop on each end of the inner border; of these the adjacent ones are well marked, and the remote ones little marked. External to the adjacent loops the borders of the lakes are a little crenate. There is a small internal median loop of the internal enamel border at the notch. The crowns of the teeth are a little wider than long, and they are not curved. The palate notch reaches as far forwards as the posterior border of the second true molar, and the palatal foramen is opposite the front of the third true molar. The latter tooth is a little longer than the other true molars. The second premolar is short and robust. The diastemata are rather short, as can be seen by the appended measurements.

Measurements.	M.
No. 1. Escuela des Minas.	
Length of precanine diastema	.020
Length of postcanine diastema	.074
Length of molar series	.151
No. 2. Museum Nacional.	
Diameters of P-m. ii { anteroposterior	.030
Diameters of P-m. ii { transverse	.024
Diameters of ?P-m. iii { anteroposterior	.024
Diameters of ?P-m. iii { transverse	.027
Diameter of ?P-m. iv { anteroposterior	.025
Diameter of ?P-m. iv { transverse	.028

This species differs from the *Equus andium* Wagn., so fully described by Branco,* in the absence of a facial fossa. From *Equus caballus* it differs in the short diastemata, and the little posterior production of the maxillary bone. How it differs from the species of the *asinus* section I do not yet know.

Equus excelsus Leidy, Extinct Mammalia Dakota and Nebraska, 1869, p. 266; pl. xxi, fig. 31.

*In Dames and Kayser Palæontologische Abhandlungen, 1883, p. 110, Dr. Branco furnishes reasons for believing that the *E. argentinus* Burm. is the same species

A portion of a left maxillary bone supporting the true molars of a horse from the Oregon desert, received from Professor Condon, resembles closely the type specimen from Nebraska described by Leidy as above. Two skulls, in the two museums of Mexico already referred to, present the same dental characters. In identifying the Mexican with the Oregon and Nebraska horses, I wish to be understood as making a provisional arrangement only, for unfortunately the cranium of the North American horse with this dentition is yet unknown. The uncertainty attending a dental identification being admitted, I proceed to the description.

This species differs from the others, whose remains have been found in the valley of Mexico, in the elongate and flattened form of the lobe formed by the section of the anterior internal column of the superior molar. This long diameter generally exceeds the half of that of the crown of the tooth by one-eighth the latter, and is rarely so short as one half of the same. The loops of the lakes are few, including only one near the posterior borders near the internal side and one on the anterior border of the posterior lake. There is generally a little loop at the notch between the two internal lobes. Crowns straight, second superior premolar elongate and acute.

One of the crania is complete, lacking only the lower jaw, and the two third true molars. The other lacks all posterior to the palatal notch. From the former I derive the following characters:

The apex of the nasal bones is above the superior canine tooth. The posterior border of the nares marks the middle of the anterior column of the third premolar. The infraorbital foramen is above the posterior edge of the second column of the fourth premolar. There are two notches on the anterior part of the superciliary border; and there is a short exostosis on each side of the front, in line with the supraorbital border, in front of the preorbital border.

Measurements.	M.
Length from superior edge of foramen magnum to incisive border	.565
From posterior nares to incisive border	.300
Interorbital width	.166
Length of series of molar teeth	.191
" precanine diastema	.022
" postcanine "	.056
Width of palate at third incisors	.092
" " canines, inclusive	.075
Diameters P-m. ii { anteroposterior	.0425
Diameters P-m. ii { transverse	.0275
Diameters P-m. iii { anteroposterior	.032
Diameters P-m. iii { transverse	.034
Diameters M. iii { anteroposterior	.0335
Diameters M. iii { transverse	.029

The internal anterior column of the superior molars is longer and flatter than in the specimens of the North American horse, but I do not feel at liberty to propose a new specific name for the Mexican animal. The absence of facial fossa and short diastemata throw it into the series of the asses. From all these the large flat internal column distinguishes it. The presence of the loop at the notch of the internal border in the Mexican specimens distinguish them from Leidy's type and from one of Condon's specimens. A second one of the latter has a small loop at the point in question. The absence of this loop is given by Leidy as characteristic of the *E. occidentalis*, but only a small proportion of my specimens of that species are without it.

The Mexican specimens are from Tequixquiac.

EQUUS BARCENÆI Cope, sp. nov.

Two superior molars represent this species in the Museum Nacional, and two superior molars in the Escuela des Minas. A skull lacking all in front of the orbits inclusive, in the latter museum, probably belongs to the same species.

This horse is distinguished from all the others here mentioned or described by its small size. In the characters of its superior molars it is like the *Equus excelsus*. The anterior internal column is flat, and its anteroposterior diameter is five-eighths that of the crown of the tooth. The prism is straight. The lakes have the margin but little looped; the posterior notch of the anterior lake is trebled or triplex. The grinding face of the crown of the third superior molar is a little longer than the others.

Measurements.		M.
Diameters of molar No. I	anteroposterior	.0215
	transverse	.0230
Diameters of molar No. II	anteroposterior	.022
	transverse	.022

From Tequixquiac.

I have dedicated this species to my distinguished friend Mariano de la Barcena, Professor of Geology in the National Museum and Director of the Meteorological Observatory of the City of Mexico.

PLATYGONUS Leconte.

PLATYGONUS ?COMPRESSUS Leconte.

A portion of the mandibular ramus of a species of peccary, apparently the above, was found at Tequixquiac, and is preserved in the museum of the College of Guanajuato. Dr. Alfredo Dugés, the distinguished professor in the college, called my attention to the specimen, and gave me a cast of it. Its dimensions are similar to those of North American individuals, as follows :

Measurements.		M.
Diameters of M. i	anteroposterior	.0145
	transverse	.012

	Measurements.	M.
Diameters of M. ii	anteroposterior	.017
	transverse	.014

HOLOMENISCUS, gen. nov.

Under the head of this genus I give a synopsis of the results of my study of the extinct Camelidæ of the American Pliocene epoch. I can compare the specimens from Buenos Ayres with those from Mexico and Oregon, and Branco and Owen have given detailed descriptions of specimens from Buenos Ayres and Mexico. From these sources I learn of the existence of the following generic forms of Camelidæ. I omit Protolabis Cope,* and refer it to a separate family—the Protolabididæ, on account of the presence of three superior incisors in each premaxillary bone, as in the primitive Ruminantia, combined with the presence of a cannon bone.

I. Premolar teeth $\frac{4}{4}$.

P-m. i separated by diastemata.....*Procamelus.*

II. Premolar teeth $\frac{4}{3}$.

P-m. ii below wanting.....*Pliauchenia.*

III. Premolar teeth $\frac{3}{3}$.

Fourth inferior premolar triangular.....*Camelus.*

Fourth inferior premolar composed of two crescents, which enclose a lake (an inferior P-m. 3?).....*Palauchenia.*

Fourth inferior premolar composed of two crescents, with two posterior tubercles behind them.....*Protauchenia.*

IV. Premolar teeth $\frac{2}{1}$

Fourth premolar below triangular.....*Auchenia.*

V. Premolar teeth $\frac{1}{1}$

Fourth superior premolar composed of two crescents.....*Holomeniscus.*

Fourth superior premolar consisting of a simple cone.....*Eschatius.*

The position of this genus being determined as above, it remains to examine the material representing it, at my disposal.

In 1873 Dr. Leidy† described a large species of llama from specimens from California, which include the entire inferior series of molar teeth, and one superior molar. The first inferior molar, properly the fourth premolar, has the crown partially worn, showing that it was opposed by a grinding tooth in the superior series. In the Museum Nacional of Mexico is preserved a complete mandibular ramus, containing all the teeth of one side of an animal smaller than Dr. Leidy's type, but having a general resemblance to it; including the worn fourth premolar. In the collections of Professor Condon and myself from the Oregon desert, there are various isolated molars agreeing in measurements with Dr. Leidy's type, and belonging probably to the same species. In the Condon collection is part

* Proceedings Academy Philadelphia, 1876, p. 145.

† Report U. S. Geol. Survey Terrs., F. V. Hayden, I, p. 255, pl. xxxvii, figs. 1-3.

of a superior maxillary bone which contains the M. i and the alveolus of the P-m. iv, with the foramen infraorbitale anterius. The measurements of the M. i agree with those of the corresponding tooth of the lower jaw of Leidy's specimen. In the Museum of Mexico, there are preserved several superior true molars which also agree in dimensions with the corresponding teeth of the lower series of the type of the same *A. hesterna* of Leidy. The fourth superior premolar is wanting from this series.

The fragment of maxillary bone in the Condon collection shows that this species had a large three-rooted fourth premolar. It is broken off at the anterior alveolus, but it is so attenuated at that point as to make it almost certain that there was no third premolar in front of it, as is found in the genus Auchenia.

In further evidence of the existence of a genus characterized as above, by the absence of the P-m. $\frac{3}{3}$, the jaw-fragment which represents the *Auchenia vitakeriana** may now be cited.

Holomeniscus vitakerianus Cope.

Although I ascribed a third superior premolar to this species, I must now deny its existence in the adult animal. A slight fossa on the narrow alveolar ridge indicates the possible presence of a single-rooted rudiment of such a tooth in the young. In a comparison of this species with the *Auchenia weddellii* Gervais, from the Pampean beds of Buenos Ayres, it is readily observable that the latter is a true Auchenia, with well developed P-m. 3 in the upper jaw, and that it is of larger and more robust proportions than the *H. vitakeriana*. In the only well preserved lower jaw which I possess, there is a well developed P-m. iii, a tooth found only as an occasional accident in *Auchenia lama* (teste Owen Odontography). In the *A. intermedia* Gerv., from the same locality, this tooth is wanting from one ramus, while the other displays a shallow vacuity as though such a tooth had existed in infancy and had been shed. I therefore retain these species in Auchenia.

Holomeniscus hesternus Leidy. *Auchenia hesterna* Leidy, loc. sup. cit.

The existence of superior molars in the Museum Nacional of Mexico which agree with the corresponding teeth of the Californian and Oregonian llamas has been mentioned above. I give the dimensions of these teeth as follows:

Measurements.			M.
Diameters M. i		anteroposterior	.041
		transverse	.033
Diameters M. ii	one individual.	anteroposterior	.041
		transverse	.040
Diameter M. iii	one individual.	anteroposterior	.053
		transverse	.029

* Bulletin of the U. S. Geological Survey Terrs., 1878, p. 380.

These molars are covered with a layer of cementum, which is included in the measurements.

The mandible, I am disposed to refer to a smaller variety of this species for the present. The well-worn fourth inferior premolar indicates that it could not belong to the genus Eschatius, where there is no opposing tooth in the superior series capable of producing such a result. The hook below the condyle is well developed in this jaw. The incisor teeth are narrow. The canine is small and is separated from the incisors by a diastema. The triturating surface of the fourth premolar is triangular, and includes a lake. The molars increase in size posteriorly. The mental foramen is large, and is situated behind a point below the canine.

Measurements.	M.
Length of jaw from incisive alveoli to angle	.415
Height at coronoid process	.290
" at condyle	.218
" ramus at M. i	.070
" " " middle of diastema	.040
Length of symphysis	.096
" from base of incisors to canine	.043
" " canine to P-m. iv	.092
" of all the molars	.147
Diameters P-m. iv { anteroposterior	.022
Diameters P-m. iv { transverse	.013
Diameters M. i { anteroposterior	.035
Diameters M. i { transverse	.019
Diameters M. ii { anteroposterior	.042
Diameters M. ii { transverse	.019
Diameters M. iii { anteroposterior	.048
Diameters M. iii { transverse	.016

From Tequixquiac.

A cannon bone in Condon's collection, which may belong to this species, measures fifteen and a quarter inches in length. So far as the evidence goes it may as well have belonged to the *Eschatius conidens*. According to Leidy the cannon bone of the *Auchenia californica* Leidy measures nineteen inches in length. A cannon bone of at least this size, with other bones of the skeleton, occurs in the museum of the School of Mines, and may belong to the Californian species. Whether that species is a true Auchenia or not remains uncertain, as the teeth are unknown.

ESCHATIUS, gen. nov.

This genus is well characterized by the reduction of the fourth superior premolar to a simple cone, in place of the usual double crescent characteristic of the Ruminantia generally. This is the greatest known reduction of the premolar series in the Ruminantia, exceeding anything in the Bovidæ, a family otherwise more specialized than the Camelidæ. If my

identification of mandibles be correct, there is but one inferior premolar, which is not prismatic, but has two divergent roots as in Auchenia. The crown is compressed. In any case this genus is distinct from Palauchenia Owen, which is said to have the fourth inferior premolar composed of two crescents, somewhat as in the Protauchenia of Branco. There is also a simple conic third inferior premolar according to Owen. The type specimen of the type of Palauchenia, *P. magna* Owen, consists of isolated teeth put together in a bed of plaster of Paris. While there may be some uncertainty as to the position of the third premolar, I cannot agree with Professor Leidy* in the supposition that these teeth have been inverted by their describer, and really belong to the upper jaw. The specimen is preserved in the museum of the School of Mines, and I did not observe any second one.

ESCHATIUS CONIDENS, sp. nov.

Primarily established on a superior maxillary bone, which contains all its teeth, which is preserved in the Museum Nacional of Mexico. I cannot distinguish from this individual another one which was found by Mr. C. H. Sternberg in the desert of Oregon, and which is represented by a good many fragments, including parts of both jaws. I describe the Mexican specimen first.

The true molars increase rapidly in size posteriorly. The vertical ribs of the external anterior horns of the external crescents are very strong, and the external wall of the anterior crescent has a low rib on the median line also. The posterior internal crescent of the last superior molar (which is not much worn) sends its anterior horn to the external wall, thus cutting off the posterior horn of the anterior internal crescent.

Measurements.	M.
Length of the four superior molars	.126
" " M. i	.041
Diameters of M. ii.. transverse at base	.024
Diameters of M. ii.. anteroposterior	.044
Length of M. iii	.051

The *foramen infraorbitale anterius* issues above the anterior rib of the posterior crescent of the first true molar. The specimen is from Tequixquiac.

The Oregon specimen includes a left maxillary and mandibular bones, with the roots or alveoli of the teeth remaining, together with numerous bones of the skeleton. As one or two teeth of the *Holomeniscus hesternus* are mingled with the other pieces, it becomes uncertain to which of the species some of the bones should be referred. This is the more difficult, as the superior molar teeth of the two animals are of nearly the same dimensions. The probabilities are, however, that the greater number accompany the species represented by the jaws. I proceed to describe the latter.

In the maxillary bone the single alveolus of the fourth premolar is close

* Report U. S. Geolog. Survey Terrs. I, p. 256.

to that of the anterior root of the large first true molar. Its section is a wide oval. The base of the second true molar is not longer than that of the first true molar. The external wall of the maxillary bone is broken so that the position of the infraorbital foramen cannot be positively ascertained. A narrow groove, which may be a part of the infraorbital canal, is exposed, and is continued forwards to a point anterior to the first premolar, where it probably issues. If this be a correct inference, its position is anterior to that observed in the Mexican specimen. The palatine foramen issues opposite the anterior root of the first true molar. In the *Holomeniscus hesternus* this foramen issues opposite the fourth premolar's internal root.

The fragment of mandible is the anterior part of the left ramus, including the premolar and half the symphysis. The fundi of the anterior alveoli only are preserved. That of the canine is smaller than those of the incisor teeth, and is close to that of the external incisor. The mental foramen is large, and is situated posterior to the mouth of the alveolus of the canine. The symphysis is not coössified. The alveolar edge of the diastema is narrow, and presents a narrow vertical parapet outwards, which makes an angle with the external convex side of the ramus. The inferior outline below the diastema is a little concave. The roots of the premolar are well separated. The crown is lost. The coronoid process, supposed to belong to the same species, is like that of the llama, near the condyle, and is quite elevated. It maintains its anteroposterior width to near the summit. Anterior edge rounded, the bevel extending on the external face towards its base. The posterior rotula of the condyle is median, and not on one side as in the llama and in the camel. The anterior part of the face presents forwards as in the llama, and is not so much expanded as in the camel. The petrous bone is as large as that of the camel, and has a more widely open styloid fossa, which is directed more inwards in the downwards direction. The face also for the paroccipital process approaches much more nearly to its fundus than in either the camel or the llama.

Measurements.	M.
Long diameter of alveolus of superior P-m. iv	.009
" " " " M. i	.036
" " " " M. ii	.038
" " " inferior P-m. iv	.022
Length of inferior postcanine diastema	.070
Depth of ramus at middle diastema	.035
" " P-m. iv	.045

It still remains to be ascertained whether this Oregon Eschatius belongs to the species that is found in the Pliocene beds of the valley of Mexico.

Eschatius longirostris, sp. nov.

This llama is known to me from a right mandibular ramus, which is broken off behind the last molar tooth, and which supports the symphyseal portion of the left ramus, less its external wall. In size this species is be-

tween the *Auchenia weddelli* Gerv. and the *Eschatius conidens*, having just about the dimensions of the *Camelus dromedarius* or the *Palauchenia magna* Ow. It differs from the *Eschatius conidens* in the much longer inferior diastema, longer, coössified symphysis, and smaller true molar teeth; the comparison being made with superior molars of the *E. conidens*.

The alveolus of the inferior canine tooth is small, and is a short distance posterior to the third incisor, being separated by a short diastema. The mental foramen is very large, three times the size of that of the *E. conidens*, and its anterior edge is 20 mm. posterior to the canine alveolus. The alveolar parapet of the diastema is not so elevated as in *E. conidens*, but is distinct. The dentition shows that the animal is an old one. The fourth premolar has two divaricate roots, which spread nearly as far anteroposteriorly as those of the first true molar. The crown is compressed. Apex broken. The crowns of the molars are worn; that of the first to the roots. The heel of the third true molar is lost.

Measurements.	M.
Width of mandible at inferior canines	.027
Length of inferior postcanine diastema	.110
" " molar series	.132
" " P-m. iv	.027
" " M. i	.029
" " M. ii	.034
Width of " M. ii	.022
Depth of ramus at middle diastema	.043
" " P-m. iv	.058

From the Oregon desert; Professor Condon's collection.

BOS Linn.

Bos latifrons Harlan.

This species is represented by numerous remains, and must have been abundant in Mexico during the Pliocene epoch.

On the structure of the feet in the Extinct Artiodactyla of North America.
By E. D. Cope.

(*Read before the American Philosophical Society, August 15, 1884.*)

The structure of the feet of a number of the Artiodactyles of the Tertiary beds of North America has already been described. In this paper I enumerate these, and add descriptions of some types which have been hitherto unknown. I commence with the Bunodonta.

Bunodonta.

Pantolestes Cope.

The structure of the tarsus only of this Eocene genus is known.*

* Cope, Proceedings American Philosophical Society, 1881, p. 188. Pal. Bulletin, No. 34.

The cuboid and navicular bones are distinct from each other and from the cuneïforms, and the ecto- and mesocuneïform are coössified. There are four metatarsals. The laterals (ii and v) are slender; and the medians are distinct but appressed, their adjacent sides being flattened. This foot structure is remarkably advanced considering the early age, Wasatch Eocene, of the period of its existence, and the primitive, tritubercular bunodont character of the superior dentition. The selenodont types which appear first in our series of formations, the Oreodontidæ of the White River low Miocene, present a much more primitive type of foot. The camel series is remarkable for the early and continued absence of the first and fifth metapodial bones. The first known of the line, Poëbrotherium, from the White River beds, has only minute rudiments of them. It is probable the Pantolestes, or some member of the Pantolestidæ, is an ancestor of Poëbrotherium, with a number of lost types intervening.

Elotherium Aym.

The first information respecting the structure of the feet of this genus was furnished by Marsh.* He says "The radius and ulna were separate or very loosely united. The third and fourth metacarpals were nearly equal in size, and the second and fifth longer than the corresponding bones of the pes. In the latter the first digit was wanting, and the fifth rudimentary." This description leaves us in the dark as to the development of the second digit in the posterior foot and of the second and fifth in the anterior foot. The ambiguous language led me to infer that there are four digits of the anterior foot of the animal described by Marsh, and hence to separate it generically from Elotherium. The first definite information is derived from Kowalevsky, from his great memoir on the genus Anthracotherium.† He here states distinctly that the genus is bidigitate, but with small rudiments of the second and fifth metapodial bones. He shows also that the lunar is equally supported by the magnum and unciforum. In a memoir especially devoted to this genus‡ he also shows that the cuboid, navicular and cuneïforms are distinct, while the ecto- and mesocuneïforms are coösified, the entocuneïform being absent. The structure of the tarsus in this genus is then as in Pantolestes, and from this genus or one of the same family, Elotherium no doubt took its origin through intermediate genera.‖

Selenodonta.

Oreodon Leidy.

We owe to Leidy the following statement regarding the foot structure of this genus.§ What are supposed to be the bones of the forearm and leg

* American Journal Sci. Arts, 1873, p. 487, June.

† Palæontographica, 1873, p. 188, August ?

‡ Loc. cit., xxii, N. F. II, 7, p. 415.

‖ I have given the structure of the anterior leg and foot in *Elotherium imperator*, Bulletin U. S. Geol. Surv. Terrs., Vol. v, p. 60.

§ Extinct Mammalia of Dakota and Nebraska, 1869, p. 72.

are discrete, as in the hog; and the bones of the feet correspond in number with those of this animal. In 1873, Professor Marsh confirmed these statements as regards the metacarpal bones,* and added "that the navicular and cuboid bones were loosely coösified or separate." In 1884† I gave a full account of the structure of the limbs in this genus. I mentioned a peculiar feature of the carpus, viz.: that the os lunare is supported below by the inward extension of the unciform, so that the magnum is below the scaphoideum. I also showed that the cuneïforms are distinct, and that the entocuneïform is wanting.

Eucrotaphus Leidy.

I have already stated that this genus is tetradactyle anteriorly and posteriorly.‡ I now add that the structure of the limbs and feet is in other respects like that of Oreodon. This is true of the inner extension of the unciform, so that the magnum is below the trapezoïdes. The inner side of the latter bone in the *Eucrotaphus pacificus*, is so excavated, that there was plainly a free trapezium of small size. In the posterior foot the entocuneïform is wanting, and the mesocuneïform is distinct from the ectocuneïform.

Merycochœrus Leidy.

The first information of the foot structure of this genus is contained in my paper on the Oreodontidæ above cited.‖ The fore and hind feet are there stated to be tetradactyle. I now add that in the *M. montanus* Cope, the os magnum is entirely below the scaphoid, and that there is a distinct trapezium. The posterior foot is constituted as in Eucrotaphus; I also observe that the navicular has a peculiar little facet on its distal face near the front of the external edge. This fits a corresponding facet which forms the proximal surface of a ledge, which extends from front to rear on the inner side of the cuboid. In *Eucrotaphus pacificus* the arrangement is similar, excepting that the ledge of the cuboid is interrupted at the middle by a deep excavation. In *Merychyus arenarum* the cuboid is like that of *Merycochœrus montanus* in regard to this ledge.

Merchyus Leidy.

The limbs and feet in this genus are quite as in Merycochœrus. The species which I have examined is the *M. arenarum* Cope.

Leptomeryx Leidy.

We possess as yet no information regarding the limbs and feet of this genus. It is therefore fortunate that I obtained in the White River bed of North Eastern Colorado, in 1879, a nearly entire skeleton of the *L. evansi* Leidy. The bones were all found close together, and belong to two individuals, and are without admixture of those of any other species.

* Amer. Jour. Sci. Arts, p. 409; Marsh does not credit Leidy with his previous observations.

† Proceeds. Amer. Philos. Society, Pal. Bulletin, No. 38, pp. 503—10.

‡ Loc. cit., p. 504.

‖ Proceeds. Amer. Philos. Society, 1884, p. 504.

From these, and inferentially from other specimens, is derived the curious fact, that there are four distinct metacarpals, all supporting digits, while there are but two metatarsals, which are coösified into a cannon bone. This diversity between the limbs is unparalleled, although an approach to such a condition is seen in the peccary. In this animal, as is well known, there are four distinct digits in the manus, while in the pes, the metatarsals are coössified proximally, and the fifth metatarsal is reduced to a scale. This difference between the two limbs is a further illustration of Mr. Ryder's statement that the posterior limb is in advance of the anterior in grade of development, for which I have endeavored to account by reference to the fact that it is the posterior foot which receives the greater number of impacts in progression. This is because the hind limb is the principal propeller of the body.

In accordance with the structure of the feet, the fore-limb is much behind the posterior limb in the fixity of its parts. The ulna and radius are distinct; the head of the latter a regular transverse oval. The distal extremity of the fibula is not coössified with the tibia, but forms a separate bone, as in the Ruminantia.

The lunar is mainly supported by the unciform, so much so that the front face of the magnum is not beveled to fit the former. Behind the face, the edge of the magnum is a little beveled for the lunar; but the former bone lies almost entirely under the scaphoid. The trapezoïdes is coössified with the magnum. No distinct trapezium.

The cuboid and navicular are solidly united. The ecto- and mesocuneïforms are distinct, and there is no entocuneïform. The second metatarsal is represented by a flat oval bone which is borne on the underside of the projecting heel of the third metatarsal. The fifth is of smaller size, and is a scale imbedded in a depression of the posterior part of the side of the fourth. Ungues unilateral, trihedral and acute.

Hypertragulus Cope.

Remains of this genus are as abundant in the White River beds as are those of Leptomeryx, and like that genus I know but the one species, the *H. calcaratus* Cope. Unfortunately I have not been able to obtain bones of the skeleton connected with dentition from this formation, although numerous bones occur separately which probably belong to it. The genus is however abundantly represented in the John Day Miocene beds of Oregon, where Leptomeryx does not probably occur. At least no specimens of the latter are to be found in a collection of between one and two hundred individuals of this general type in my collection. I cannot distinguish the John Day species from the *H. calcaratus*, although the size is generally distinctly larger.* In other cases the size is the same. To the John Day specimens then I refer for the characters of the feet of this genus.

* It is probably this species that is cited by Leidy as the *Leptomeryx evansi* in the Report U. S. Geol. Survey Terrs. I, p. 216.

The ulna and radius are coösified. The scaphoid and lunar facets of the radius are well distinguished by an oblique ridge. The carpus is unknown. The median metacarpals are separate; whether the second and fifth are well developed I do not know, but suspect them to be so, as in Leptomeryx, since the third and fourth bear no adherent rudiments. The cuboid and navicular bones are united, while the cuneïforms are distinct from them and from each other, as in Leptomeryx. There are but two developed metatarsals, and these are distinct from each other. Thus the fore-limb in its ulno-radius exhibits a little advance over Leptomeryx; while in the separate metatarsals it is behind the latter.

Hypisodus Cope.

This genus is remarkable for its prismatic dentition, being the only Artiodactyle presenting the character in the White River fauna.* It was probably well advanced in foot characters, but of these I know but little. Parts of two tarsi found with the jaws of the *H. minimus* Cope, are referred to the species on account of their very small size, and general correspondence. The cuboid and navicular are coössified. Their distal face, especially the navicular part, is so narrow transversely, that it is almost certain that the third and fourth metatarsals are coössified, and that the second and fifth are rudimental or wanting. There is no trace of facets for the latter on the naviculo-cuboid.

Poëbrotherium Leidy.

I have fully described the limbs of this genus in the Annual Report of the U. S. Geological Survey of the Territories for 1873†, as seen in the *P. vilsoni* Leidy, from the White River beds, and have confirmed them from a fine specimen of the *P. sternbergi* Cope, from the John Day or Middle Miocene of Oregon.‡ The characters are; ulna and radius coössified; trapezium and trapezoïdes present and distinct; magnum supporting part of lunar. Two distinct metacarpals, scales representing the second and fifth; navicular and cuboid bones distinct, as are the ecto- and mesocuneïforms; entocuneïform wanting. Metatarsals two, distinct; second and fifth represented by scales.

Observations on the Phylogeny.

I have maintained ‖ that the selenodont dentition is a derivative of the bunodont, a proposition which seems unavoidable from a mechanical point of view. The testimony of palæontology is also in its favor, since in America the oldest artiodactyle, Pantolestes, is bunodont. Kowalevsky in the phylogenetic table given in his monograph of Anthracotherium§ does

* See Cope, Annual Report U. S. Geological Survey Terrs., 1873, p. 501, where the cuboid and navicular are stated to be united.

† 1874, p. 499.

‡ Bulletin U. S Geol. Survey Terrs. V, p. 59.

‖ Journal Academy Natural Sciences, 1874. See also Ryder, The Mechanical Genesis of tooth forms, Proceeds. Academy Philada., 1879, p. 47.

§ 1873 (?4), p. 152.

not commit himself as to this point, but allows the development of the two types of dentition to appear to have been cotemporary and from some common origin. He then derives from such a common point of departure first, the Hyopotamidæ, which first appear in the Eocene, and second, the ancestors of the Anoplotheriidæ. From the Hyopotamidæ he derives all the modern Selenodonta, exclusive of the Camelidæ. The latter group he omits from his table, doubtless because his information on the subject was insufficient. The main line of origin of the Selenodonta is divided early in Miocene time, the genus Gelocus giving origin to the Pecora, and the genus Hyæmoschus to the Tragulina.

In describing the characters of the genus Poëbrotherium for the first time, I remarked as follows :* "The present genus is a more generalized type than Gelocus, and in its distinct trapezoïd and distinct metacarpals represents an early stage in the developmental history of that genus. It also presents affinity to an earlier type than the Tragulidæ which sometimes have the divided metacarpals, but the trapezoïdes and magnum coössified. In fact Poëbrotherium as direct ancestor of the camels, indicates that the existing Ruminantia were derived from three lines represented by the genera Gelocus for the typical forms, Poëbrotherium for the camels and Hyæmoschus for the Tragulidæ."

These views being then established on sufficient evidence, it remains to make such additions as the facts cited in the present paper indicate. First in importance comes the place in the phylogeny of the Selenodonta, of the Oreodontidæ. The peculiar inward extension of the unciform bone already ascribed to them, characterizes also among extinct forms the genus Leptomeryx, and probably Hypertragulus. Among recent ruminants it is only seen in the Tragulidæ.† If we arrange these types in serial order we find the modifications of form to be generally identical with those of the other ruminant lines, in the coössification of the bones of the legs and feet. This series may then be regarded as phylogenetic. The peculiar structure of the carpus of the Oreodontidæ, puts them out of the question as ancestors of any type of existing ruminants other than the Tragulina. Whether they themselves can be traced to a five lobed, or to a four-lobed bunodont ancestor, remains an undecided question. It is not, however, probable that a five-lobed form has been intercalated in a series, both of whose extremities are four-lobed. If this be true, the Oreodontidæ must be regarded as an ancestral type of Selenodonta, coëqual with the Hyopotamidæ, and it may well be questioned whether the latter can have been ancestors of the existing Ruminantia, whose molars are four-lobed.

So the present investigation does not disclose the ancestral stock of the Pecora. In North America we have not progressed further in the solution of this question than I reached in 1877,‡ after a study of the genera

* Bulletin U. S. Geol. Survey Terrs. Vol. i, No. 1, p. 26, Jan., 1874.

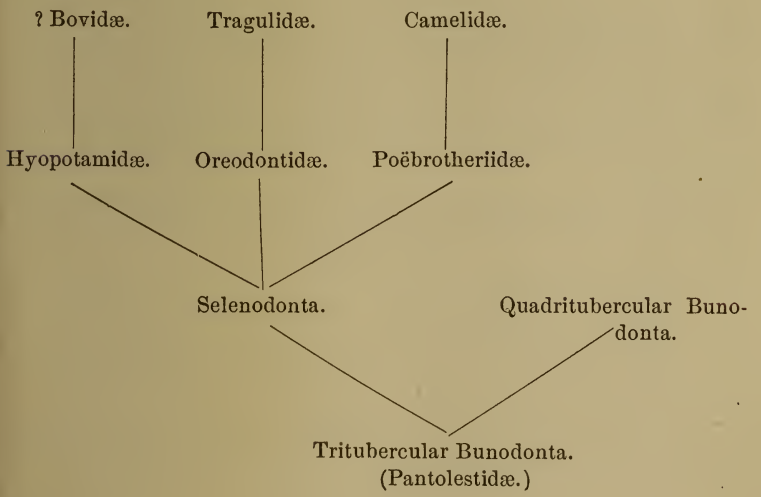
† Among Perissodactyles it occurs in Triplopus, Tapirus and the Rhinocerontidæ.

‡ Proceedings Amer. Philos. Soc., p. 223.

Cosoryx Leidy, and Blastomeryx Cope. I had already* suggested that the former genus is the ancestor of the Cervidæ, but subsequently† remarked: "It is not probable this genus is the immediate ancestor of Cervus, from the fact that the molar teeth display in their prismatic form a higher degree of specialization than belongs to that genus. It is probable that the true ancestor combined the dental type of Cervus with the distinct roots and short crowns of the molars, with the type of horns here described." I at that time included a species (*Cosoryx gemmifer* Cope) in the genus, provisionally, which has the type of molars in question. Having discovered another, larger species, which has the same type of molars, I at once distinguished the provisional group in which I had placed the *C. gemmifer*, Blastomeryx, as a genus; and in describing the species (*B. borealis*) observed as follows:

"In brief, its molars differ from those of Cosoryx ("Dicrocerus") much as those of the deer differ from the molars of the antelope. While Cosoryx ("Dicrocerus") was probably the ancestor of Antilocapra, Blastomeryx was the ancestor of Cervus or Cariacus." This opinion expresses all the information I possess on the subject at present. It remains to ascertain the structure of the anterior feet in Hypisodus, which is the earliest genus of Ruminantia known to have prismatic molars.

The following table will represent the views expressed in the preceding pages:



* Proceedings Academy Philadelphia, 1874, p. 149.

† Report Expl. Surv. W. of 100th Mer. U. S., G. M. Wheeler in charge, iv, pt. ii, p. 349, 1877.

*Fifth Contribution to the Knowledge of the Fauna of the Permian Formation of Texas and the Indian Territory. By E. D. Cope.**

(*Read before the American Philosophical Society, August 15, 1884.*)

PISCES.

CERATODUS FAVOSUS, sp. nov.

This species is known to me from a piece of the lower jaw, which supports a tooth. One extremity of the tooth is broken off, but from the curvature of its inner side, it is to be inferred that the portion lost is but small, probably including one of the three processes which the tooth possesses. The species may be distinguished from those described by Agassiz, and from the existing species, by the great depth of the two emarginations of the external side. These enter the crown so deeply as reduce its width to dimensions no greater than those of each of the processes of the crown. The internal face is strongly convex, and one extremity is more strongly recurved than the other. The crown consists of a mass of coarse perpendicular simple calciferous tubules, which are enclosed in a rather thin layer of a dense substance which thickens downwards, and laps over the external face of the jaw bone. The external surface of this layer is vitreous. The walls of the tubules are of a dense and hard substance, of a darker color in the fossil, and the tubules are filled with a softer substance, so that the grinding surface of the crown has the appearance of a small honeycomb. The diameter of the tubules ranges from 1. to .05 mm. The fragment of jaw is robust, is deeper than wide, and is strongly convex on the internal face. The internal inferior angle rises at one extremity above the level of the external inferior angle. The processes of the crown project freely beyond the bone, having rested on the cartilage which forms the external face of the jaw, as Günther has shown to be the case in the *C. forsteri*.

Besides the deep emarginations of the crown, the coarseness of the calciferous tubules is a special character of this species.

Measurements.	M.
Depth of jaw with tooth	.019
" " without tooth	.012
Width of crown at middle process	.014
Probable length of crown	.022

Found by Mr. W. F. Cummins.

Agassiz did not record any species of this genus from below the Trias, but Fritsch has reported them from the Permian of Bohemia.

BATRACHIA.

CRICOTUS CRASSIDISCUS, sp. nov.

Accession of additional material enables me to add several points to the

* The "Fourth Contribution" will be found at page 628 of these Proceedings for the year 1883.

knowledge of the osteology of this genus, and to distinguish satisfactorily three species. I have much pleasure in obtaining these additional facts, since everything relating to this curious genus is of interest.

In the first place, the neural arches are not coössified to the centra, but are readily separated from them. Their basis of attachment forms, on each side of the median neural canal, an oblique triangular surface looking forwards and upwards, with the apex above and behind. The ease with which the neural arches separate accounts for the rarity of their occurrence on separate centra. They support the diapophyses at their lower border. Second, that the sacrum consists only of a centrum and an intercentrum, both of which take part in furnishing a concave facet for the attachment of the pelvis. Third, some of the ribs are two-headed, and their capitular articulation is with the posterior edge of the intercentrum. Fourth, there is a hyposphenal articulation, as in the genera of Jurassic Saurians, Camarasaurus, Amphicœlias, etc., and in the Permian genus Empedias, among the Theromorpha. The hypantrum has, however, this peculiarity : that its sides are produced forwards into a process on each side below the prezygapophyses, each of which is subconical in form, but with the interior face excavated to receive the hyposphen, so that the section of the process is crescentic. These processes I have never previously observed. I call them hypantrapophyses. I find them in the *Cricotus hypantricus*. The neural arches of the other species are either lost or in such close juxtaposition that I cannot see them.

The species differ in part as follows; the full characters can only be given in more detailed descriptions of more perfect specimens.

I. Dorsal intercentra much narrowed or pinched above.
Hypantrum unknown..... *C. heteroclitus.*

II. Dorsal intercentra equally robust above as below, or more so.
Hypantrum unknown..... *C. crassidiscus.*
Hypantrum with acute lateral processes..... *C. hypantricus.*

The measurements of the *C. crassidiscus* are as follows:

Measurements.		M.
Diameters of dorsal centrum behind	vertical	.025
	transverse	.025
Length of do.	middle line below	.013
	at base of neural arch	.013
Base of neural arch	width	.010
	length	.009
Diameters of a dorsal intercentrum	vertical	.025
	transverse	.025
Length of do.	middle line below	.009
	" " above	.0095
Diameters of coracoid	transverse length	.027
	width at glenoid face	.029
	width at internal face	.010

It is probably this species which I have figured in the Proceedings of the American Philosophical Society,* and American Naturalist,† under the name of *C. heteroclitus*. It is the most abundantly represented in my collection. In the specimen figured in the American Naturalist, the probable scapula is visible on both sides, but the coracoid is concealed by the pectoral scuta.

CRICOTUS HYPANTRICUS, sp. nov.

This Embolomere is probably represented by two individuals, which are of larger size than any species which have hitherto come under my notice, one of them very much larger. It is only the smaller specimen which is accompanied by the astragalus. Both of them display the hypantrapophyses already mentioned in remarks on the genus under the head of *C. crassidicus*.

As already pointed out in the key of species, the dorsal intercentra in the *C. hypantricus* are stout and not narrow above, but the thickness increases rather than diminishes upwards. They thus differ from the corresponding intercentra in the *C. heteroclitus*. In many of the dorsal intercentra the dense external layer which covers the inferior face continues upwards to an apex, the articular surfaces of the two ends meeting so as to exclude the former. This is also the case in the *C. crassidiscus*. The centra have the abbreviated form characteristic of the genus, and the foramen chordæ dorsalis is present, but is smaller than the *C. heteroclitus*.

The supposed astragalus is oblong ; proximal‡ border longer than the distal, which is separated by an obtuse angle from the ectad ; distal entad not reaching superior surface of bone, long, extending inwards below the revolute proximal part of the entad face, from which it is separated by a narrow oblique groove. Proximal and distal entad separated by notches of the two faces ; a ridge the length of the bone below.

Measurements.		M.
Diameters of centrum of individual with astragalus.	anterposterior	.015
	transverse	028
Diameters of astragalus	anterposterior	.038
	transverse	.029
Diameters of centrum of larger individual.	anteroposterior	.018
	transverse	.038
Diameters adjacent intercentrum of do.	anteroposterior	.013
	transverse	.038

REPTILIA.

CLEPSYDROPS LEPTOCEPHALUS, sp. nov.

This species is represented by almost the entire skeleton, the principal deficiency being that of the scapular arch and the anterior limbs, with the

* 1881, pl. ii, figs *a–b*.

† 1884, p. 39, pl. v and fig. 7. In pl. v, figs *f* and *g* represent the *C. heteroclitus*.

‡ I determine the ends of this specimen from a foot of Eryops.

phalanges of the posterior feet. The bones of the skull are mostly preserved, but in a dislocated condition. They serve to demonstrate some of the characters of the genus and family.

The quadrate bones of both sides are distinctly displayed. They are rather short, and articulate above by squamosal suture with the squamosal bones, which overlap them posteriorly. They narrow upwards, and are deeply grooved on the anterior face below. Each edge of the groove is produced forwards; the external for a considerable distance as an acuminate laminiform process, in the usual position of a quadratojugal bone. The production of the internal edge is shorter, and its extremity is vertically truncate. Its superior edge fits an incurvature of the superior edge of the pterygoid bone, and its internal face is applied to the external face of the latter.

The pterygoid bone displays the subtriangular plate with dentigerous edges, such as I have already described as present in the species of Dimetrodon. In this species it is thinner and less massive than in any species of that genus yet known. This specimen enables me to locate it more precisely than heretofore. The pterygoids were probably placed much as I have represented them to be, in the *Empedias molaris* Cope (Proceedings American Philosoph. Society, vol. xix, p. 56, pl. v). They send inwards a subtriangular plate from each side, which approach each other on the median line without touching, and the adjacent edges are somewhat decurved. The posterior edges are deeply concave on each side of the middle line, and like the inferior edges, are dentigerous. The process for the quadrate extends outwards and backwards, and is thickened on its posterior edge, while its anterior edge, which is continued from the inferior edge of the posterior border, becomes very thin. The anterior production for the ectopterygoids extends outwards and forwards, leaving the anterior edge of the dentigerous plates as the concave posterior border of the large palatine foramina. The anterior production of the internal edge of the plate becomes very thin, and is broken in the specimen without showing articulation for the palatine.

The squamosal extends both above and below its anteriorly directed zygomatic portion. The superior extremity shows squamosal suture for the parietal.

The stapes is of large size. It consists of a stout rod terminating in a double extremity, something like the double head of a rib. The shorter head is expanded into a funnel shape. Near to it the shaft is perforated in the longer diameter by a foramen. The extremity of the other head is transversely truncate and is separated from the funnel by a deep notch. On the outer side of the fundus of this notch, a foramen penetrates the shaft obliquely and is continued into a canal which issues at the foramen first described. The distal end is truncated by an irregular sutural surface. In the specimen the bone lies behind the squamosal and quadrate bones, the simple extremity of the rod near the posterior edge of the quadrate.

The premaxillary bones are distinct. The teeth of that bone and of the maxillary are of unequal sizes.

The axis has an expanded neural spine, and a diapophysis for rib articulation, but no parapophysis or capitular fossa. The two latter features characterize all the vertebræ which follow, as far as the lumbar series.

The column in the typical specimen is tolerably complete, with a break of uncertain, but probably not great length in front of the sacrum, and the loss of the distal part of the caudal series. Intercentra of rather small size are present throughout the series anterior to the sacrum. The inferior faces of the caudal vertebræ are yet concealed by matrix. The bases of the neural spines are compressed; they were probably not elongate as in Dimetrodon, though they are unfortunately broken off, except that of the third cervicodorsal vertebra. Here the spine is short and truncate above, and rather wide anteroposteriorly. As in Dimetrodon there is no distinction between cervical and dorsal vertebræ.

The pelvis is well preserved, and has the characters already assigned to the *C. natalis* Cope.* The ilium has a process or narrowed continuation with parallel sides, directed backwards and upwards, and bearing a keel on the middle line on the internal side. The ischia are much produced posteriorly, and are separated by a notch on the middle line posteriorly.

The head of the femur is expanded, including probably the homologue of the great trochanter of mammalia, and its articular face is crescentic, with obtuse horns. There is a trochanter below it on the posterior edge of the shaft. The condyles are inferior, and are separated by a deep groove above and a shallow one below. The articular faces of the two condyles are continuous, forming and ∞-shaped figure. The proximal extremity of the tibia is wider than the distal, and the articular face is uninterrupted. That of the distal extremity is a transverse oval.

Specific characters. While the vertebral centra of this species are rather short, the bones of the head are very much attenuated, and the jaws are long and slender. None of the four jaws is prefectly preserved, but the number of the teeth in the maxillary bone may be approximately fixed at thirty in a continuous series. One, and probably two of these, placed near the anterior part of the series, are larger than the others. They are placed at the position of the corresponding large maxillary teeth in Dimetrodon, but they do not display the dimensions seen in the species of that genus. To strengthen the jaw at this point, a rib rises from the thickened alveolar portion, and extends vertically on the inner side of the thin facial plate of the bone. The facial plate is double, and each lamina, except at the rib, is not thicker than wrapping paper.

The premaxillary bones are robust, and are excavated postero-laterally for a very large nostril on each side. The spine is long. The alveolar edge bears five teeth, which are followed by a diastema. These diminish in size posteriorly, the first one being the largest, and equaling the large

* Proceeds. Amer. Philos. Society, 1878, p. 509.

maxillary teeth. The last two are quite small, less than the usual maxillary teeth.

The dentary bones are very slender, and the distal end is somewhat thickened to support two teeth larger than the others. These are the third and fourth from the extremity, and are not quite so large as the large teeth of the maxillary bone. The remaining mandibular teeth are small, and are not so much compressed as in the species of Dimetrodon. Many of them have only a posterior cutting edge, which is not denticulate. The apices are strongly turned backwards in the posterior part of the series. The posterior part of the dentary bone rises and carries some of the teeth with it.

The surface of the free edge of the internal plate of the pterygoid bone is granular. The teeth on the posterior edge of the same are subconic, and in a single series.

There are twenty-seven vertebræ in a continuous series, from and including the axis. All bear diapophyses, and all are rib-bearing, except perhaps the last two, where they are of reduced size. They are more or less opposite the neural canal as far as the twenty-second centrum. On this vertebra the superior edge is on a level with floor of the canal, and posterior to this point the diapophyses rise from the centrum. Two sacrals and ten caudals are preserved, and all have diapophyses and neural spines. The centra in this species are rather short, being as deep as long throughout the series, if measured at the middle. The edges are not undulate as in *C.* (*Embolophorus*) *limbatus* Cope. The intercentra are short and not extended upwards on the sides as in that species.

Measurements.	M.
Length of quadrate bone	.085
Width of condyle of quadrate bone (greatest)	.037
Length from condyle of internal anterior process of do.	.032
" " " external " " "	.097
" of squamosal bone (vertical)	.124
" " pterygoid from palatal foramen	.116
Width " " at middle	.090
Length " internal dentigerous edge of do	.070
" " posterior " " "	.051
" " maxillary bone posterior to canine brace	.181
Thickness of " " at canine brace	.020
Depth of " " nostril	.016
Length of premaxillary bone (posterior apex restored)	.060
Width " " " at third tooth	.022
Diameter of large (first) premaxillary tooth	.008
" " " maxillary tooth (canine)	.009
" " small " "	.006
Length of crown of last maxillary tooth	.009
" " twenty-seven continuous cervico-dorsal vertebræ	.855

Measurements.	M.
Length of two sacrals	.65
" " ten caudals	.260
Diameters centrum axis: anteroposterior	.034
Diameters centrum axis: vertical posteriorly	.031
Diameters centrum axis: transverse posteriorly	.030
Elevation of neural spine from centrum	.071
" " arch " "	.009
Width of postzygapophyses	.030
Elevation of neural spine of fourth vertebra	.058
Diameters centrum sixteenth vertebra: anteroposterior	.025
Diameters centrum sixteenth vertebra: vertical at end	.035
Diameters end centrum seventeenth centrum: vertical	.034
Diameters end centrum seventeenth centrum: transverse	.030
Expanse of postzygapophyses of seventeeth vertebra	.029
Diameters twentieth centrum: vertical at end	.031
Diameters twentieth centrum: anteroposterior	.027
Diameters of twenty-ninth centrum: anteroposterior	.024
Diameters of twenty-ninth centrum: transverse behind	.035
Expanse of postzygapophyses of twenty-ninth vertebra	.024
Width of sacrum through fixed diapophyses	.049
Diameters centrum twentieth caudal: anteroposterior	.025
Diameters centrum twentieth caudal: vertical behind	.0265
Diameters centrum twentieth caudal: transverse "	.0225
Expanse through diapophyses	.047
Elevation of prezygapophyses (greatest)	.039
Diameters of pelvis: anteroposterior (apex of pubis restored)	.235
Diameters of pelvis: vertical through acetabulum	.123
Anteroposterior diameter of ilium at acetabulum	.089
Depth of ischium at posterior edge of acetabulum	.080
Length of " from acetabulum	.117
Length of femur	.179
Proximal diameter of femur: anteroposterior	.075
Proximal diameter of femur: transverse (at middle)	.025
Diameters shaft at middle: transverse	.038
Diameters shaft at middle: anteroposterior	.031
Diameters of distal end: transverse	.068
Diameters of distal end: anteroposterior, external condyle	.031
Diameters of distal end: anteroposterior, internal "	.045
Length of tibia	.150
Diameters of tibia: proximal, anteroposterior (middle)	.040
Diameters of tibia: proximal, transverse	.057
Diameters of tibia: median, anteroposterior	.019
Diameters of tibia: distal, anteroposterior	.026
Diameters of tibia: distal, transverse	.041

The typical specimen of this species was found by Mr. W. F. Cummins in the Permian beds of Northern Texas.

CLEPSYDROPS MACROSPONDYLUS, sp. nov.

This species, like the last, much exceeds the *C. natalis* in dimensions. The bases of the neural spines are enlarged, so that it is probable that the spines were not elongate as in the species of Dimetrodon. Intercentra are present throughout the dorsal and caudal series of vertebræ. The dentary bone supports one or two large teeth near the extremity. These characters furnish the reasons for referring the species to the genus Clepsydrops.

The individual by which the species is known, is represented by an axis vertebra, twelve continuous dorsal vertebræ; nine other continuous vertebræ, of which three are lumbar, two sacral, and four caudal. Also by a part of the ilium, and by the greater part of a dentary bone. All of these specimens were found together, and possess an identical mineral appearance.

That this reptile belongs to a distinct species from the *C. leptocephalus* is readily determined by the form of the dorsal vertebræ. The centra are a little longer than those of that species, but have a smaller vertical diameter. The latter is three-fifths of the former, while in the *C. leptocephalus* the two dimensions are reversed, the depth being a little in excess in corresponding parts of the column. The dentary bone, on the contrary, is more robust than that of the *C. leptocephalus*, and supports, probably, a small number of teeth.

The edges of the centra are not undulate or laterally flared. The centra are strongly compressed, and in the anterior part of the column have an obtuse hypopophysial keel. The intercentra display equal width of the inferior surface; and are abruptly rounded at the extremities. The last one preserved is between the second and third caudal centra. It is shorter and wider than the others, and does not display any trace of a chevron bone. The diapophyses are opposite the neural canal on the thirteen anterior vertebræ preserved. Each one sends a horizontal rib forwards to the prezygapophysis, and another obliquely forwards and downwards which stops short of the edge of the centrum. These ribs enclose a fossa in front of the diapophysis. Posteriorly the anteroinferior rib grows more robust, and evidently supports part of the tuberculum of the rib. There is no facet for the capitulum until the antepenultimate vertebra of the anterior series is reached. Here and on the penultimate the anterior border is flattened into a facet, and on the last of the series, the facet marks the summit of a distinct tuberosity, which is produced by the cutting away of the border below it, to accommodate the intercentrum.

The three lumbar vertebræ preserved are different from the dorsals in their greater abbreviation. This character is not unknown in other species of Pelycosauria. The centrum is contracted, but not compressed, at the middle. The diapophysis is altogether on the centrum, and supports no rib-facet. Its anteroinferior buttress is well developed, extending to the

margin of the centrum which is cut out below it for the intercentrum. The sacrum is rather robust. Its two vertebræ are not coössified, and support well developed neural spines, and a large free diapophysis for the ilium. The centra of the caudals, and their diapophyses and neural spines are well developed. There is a fossa at the base of the spine on each side, in line with the zygapophysial surfaces, equidistant between them.

The fragment of ilium is of appropriate size, and is quite robust. It displays the fossa for the sacral diapophysis, and the acetabulum. The latter is remarkable for the prominence of the tuberosity on the superior border, which exceeds that of any species of Pelycosaurian known to me. The section of the ilium through it is triangular.

The dentary bone is accompanied by the splenial to the middle of the symphysis. The latter is not very long. Its dentary portion turns upwards. The ramus is quite robust, differing much from that of the *C. leptocephalus*. It is broken off a little anterior to the tooth line, but the latter probably did not contain more than twenty-two teeth. These have anterior and posterior cutting edges, and are denticulate. The external face of the dentary is excavated by shallow, undulating, branching grooves.

Measurements.	M.
Total length of vertebræ preserved	.640
Diameters centrum of a dorsal vertebra: anteroposterior	.031
Diameters centrum of a dorsal vertebra: vertical behind diapophysis	.019
Diameters centrum of a dorsal vertebra: transverse at end	.021
Diameters centrum of a dorsal vertebra: transverse at middle	.0115
Diameters neural arch of same vertebra: length with zygapophyses	.041
Diameters neural arch of same vertebra: width at prezygapophyses	.022
Diameters neural spine of same vertebra: anteroposterior	.0145
Diameters neural spine of same vertebra: transverse behind	.007
Diameter of intercentrum of do: anteroposterior	.0052
Diameter of intercentrum of do: transverse	.023
Diameters of a lumbar centrum: anteroposterior	.024
Diameters of a lumbar centrum: transverse at end	.026
Diameters of a lumbar centrum: " " middle	.023
Diameters of a lumbar centrum: vertical behind arch	.022
Diameters of a lumbar centrum: " at end	.029
Length of sacrum	.055
Diameters of third caudal vertebra: anteroposterior	.024
Diameters of third caudal vertebra: vertical at end	.023
Diameters of third caudal vertebra: transverse at end	.022
Anteroposterior diameter of acetabulum	.0325
Transverse diameter of ilium at tuberosity	.0265
Length of dentary bone supporting twenty teeth	.044
Thickness at twentieth tooth	.0175
Depth ramus at second tooth	.035
" " " fifteenth tooth	.039

The bones of this specimen are in excellent preservation. They were recovered by Mr. W. F. Cummins from the Peruvian beds of Texas.

EDAPHOSAURUS MICRODUS, sp. nov.

The genus Edaphosaurus Cope, was established on the *E. pogonias* Cope (Proceed. Amer. Philos. Soc., 1882, p. 448), which is represented by a specimen, which includes only a distorted cranium, with most of the parts preserved. The present species is represented by an individual of which I possess numerous vertebræ and ribs, and the dentigerous plates of both jaws. These are part of the dentary splenial in the inferior jaw, and the pterygoid or palatine of the superior. The specimen enables me to determine the characters of part of the vertebral column in the genus Edaphosaurus.

In the first place the vertebræ possess enormously elongate neural spines, as in Dimetrodon. Next, the centra have a facet on the anterior edge above the middle for the head of the rib, as in a mammal. It is not repeated on the posterior edge of any of the thirteen centra preserved. Thirdly, the ribs are only compressed proximally. Distally their section is a wide oval. The extremity is truncate and concave. The shaft is hollow, the walls being thinnest distally.

Specific characters. The grinding teeth of this species are about as numerous as in the *E. pogonias*, there being about seven in a transverse row on each plate. They are, however, less closely placed than in the typical species, and have more conic crowns. They do not form a pavement, as they are separated by wider interspaces.

The centra are rather elongate, and the *foramen chordæ dorsalis* is rather large. No intercentra are preserved, and if present they must have been very small, as the inferior rim of the centrum is not beveled to receive one. The neural spines have transverse processes which commence near the base, and project at intervals from the sides. The inferior ones are oval or subround in section; those which succeed are more or less compressed. The extremities are enlarged fore and aft so as to be claviform in outline, but are compressed except where thickened by lateral tuberosities. These are rarely symmetrical, one being larger and situated higher up, sometimes giving the apex an unsymmetrically bilobate form. Sometimes they project at right angles to the terminal expansion. The shaft of the spine has a rather small medullary cavity, and this issues by an open mouth at the summit of the apex without constriction. This peculiar arrangement suggests a cartilaginous continuation of the spine which retains the nutritive artery of the medullary cavity. The anterior face of the shaft is grooved from the base for some distance upwards; the posterior face is plane and then rounded above.

Measurements.		M.
Diameters of inferior dental patch	anteroposterior....	.043
	transverse.....	.024

			Measurements.	M.
Diameters of a posterior dorsal centrum		anteroposterior		.0335
		vertical at end		.027
		transverse	at end	.026
			at middle	.015
Measurements of piece of spine of same		length		.132
		diameter at base.	anteroposterior	.023
			transverse	.019
Diameters of median dorsal		vertical	at end	.032
			behind arch	.025
		anteroposterior		.0465
		transverse	at end, at flare	.037
			at middle	.016
Diameters of summit of spine		anteroposterior		.032
		transverse		.032

The ramous character of the neural spines of this species is much like what is seen in the *Dimetrodon cruciger* Cope. The rami in this species, however, retain their size upwards, and become compressed, a feature not seen in the *D. cruciger*. The apices of the spines in the latter species are not dilated as in the *E. microdus*.

Found by W. F. Cummins in the Permian beds of Texas.

The posterior foot in Pelycosauria.—The foot-bones of the reptiles of the suborder Pelycosauria are abundant in the collections from the Permian formation, and I have examined my collection for specimens in which they are in normal connection, for the purpose of identifying them. I have been so fortunate as to find an entire tarsus, with the proximal parts of the metatarsi, in the skeleton which served as the type of my description of *Clepsydrops natalis*.* The characters presented by this foot are no doubt present in all of the Clepsydropidæ, which includes the genera Theropleura, Dimetrodon, Embolophorus, and probably others. Tarsal bones identical with those of the *C. natalis* were found with the original specimens of *C. collettii* and others of much larger size, accompany remains of species of Dimetrodon, or Embolophorus.

The astragalus and calcaneum are large and well specialized bones, distinct from each other and from the other tarsal elements. They do not resemble the corresponding bones of any known type of vertebrate, as will presently appear. The navicular bone is distinct, and the cuboid apparently consists of a single element. This depends on the interpretation given to a small bone on its posterior face, which is broken on its free edge, and may be the head of the fifth metatarsus. There are three elements in contact with the distal face of the navicular, which correspond with the three mammalian cuneïforms. The space available for this contact seems hardly sufficient for the three elements present, one of which is out of position and on the inferior side of the carpus. This element

* Proceedings American Philosoph. Society, 1879, 509.

looks also from its free inferior side like an ungual phalange, but is flatter than is characteristic of this family. There are three metatarsals distal to the navicular, which are well accommodated with articular facets on the distal extremities of the three bones in question, so that their identification as the three cuneïforms, is probably necessary. The two remaining metatarsals are articulated, the fourth to the exterodistal facet of the cuboid; and the fifth to the exterior side of the cuboid. The third, fourth and fifth metatarsals are directed at an obtuse angle posteriorly from the long axis of the astragalus.

This structure is more mammalian than any form of foot yet known among reptiles, and agrees with the indications of mammalian character described as existing in the long bones of the limbs by Owen and by myself.

The astragalus is an oblong bone with one long straight side, viz., that which is in contact with the calcaneum. This side has two facets for articulation with the calcaneum, which are separated by a groove, which forms a foramen when the two bones are in place. The proximal extremity of the bone is much smaller than the distal, and is subround. The proximal half of the bone would be nearly cylindric were it not for the truncation caused by the calcaneal facet. The distal half of the bone is robust, and is surrounded on all sides by facets. These are the external or calcaneal, the distal or navicular, and the internal which is larger than the other two together. The first two are oblong and truncate, the navicular twice as large as the calcaneal, its transvere much exceeding its anteroposterior diameter. The internal facet already mentioned, covers the internal face of the distal half of the astragalus, which projects further inwards than the proximal half, rising abruptly from it. The facet is continuous with the navicular, and is at right angles to its plane. It widens proximally, and its proximal border is deeply notched. Its surface is convex from back to front, but not strongly so. In the astragalus of a species of Dimetrodon, it is divided by an angle into two facets, the two faces thus produced being nearly at right angles to each other. This inferior part of the facet is continued into a prominent border which is more or less roughened. A rounded tuberosity of the inferior face of the bone occupies the space between this border and the calcaneal border, so approaching the notch already described, as to cause a groove to proceed from it posteriorly and inwards. I described the corresponding bone in the *Clepsydrops collettii* (Proceeds. Phila. Academy, 1875, p. 409) as a possible coracoid.

The calcaneum has its postero-external edge broken in the specimen of *Clepsydrops natalis* described, but is probably a semidiscoid bone, with its straight margin applied to the astragalus. This margin presents a median flat elongate-oval facet, which is separated by grooves from a facet at each end. The proximal facet is the narrower, and passes by a curve into the proximal extremital facet, which is adjacent to the corresponding proximal facet of the astragalus. The distal internal facet is triangular and wider

than long, and is separated by an angle only from the distal facet. The latter is a little more than a half circle in outline, and joins one bone of the second row, which I suppose to be the cuboid. The fact that it does not articulate with the second element in that row, leads me to suspect that the latter is the head of a fifth metatarsal. The external edge of the bone thins out more rapidly at the distal than at the proximal extremity.

The cuboid bone is pentagonal in outline, and square in transvere section. It is not unlike that of the Amblypodous Mammalia. It has a transverse proximal facet, and two distal ones which meet at an angle about right. The fifth metatarsal is articulated with its posterior face; and the fourth with the exterior distal face. The ectocuneïform articulates with the interior distal face. The navicular bone is subtriangular in transverse section, and with a subquadrate base articulating with the cuboid. Its longitudinal and anteroposterior diameters are about equal. The distal or metatarsal articulation of the entocuneïform is transverse and flat.

The manner of articulation of the ankle-joint must have been different from the usual reptilian type. The proximal extremities of the astragalus and calcaneum combined are not too large to have received the distal extremity of the fibula, so that the tibial articulation must be sought elsewhere. This may have been on the large distal facet of the anterior or inner face of the bone. A part of this facet looks upwards and probably supported the tibia, which was thus removed by a short space from that of the fibula. The down-looking part of the facet, which is more distinct in Embolophorus, must have articulated with a separate element. This may have been a spur, such as exists in the known genera of the Monotremata; as the position is identical with that which bears this appendage in those animals. It is quite evident that an element additional to those known in the ordinary reptilian foot exists in the Clepsydropidæ.

The separation of the distal extremities of the tibia and fibula is not usual among reptiles, but it is common in the salamanders, where the os centrale comes between them. It is also evident that the subcylindric proximal part of the astragalus, which intervenes between the supposed tibial and fibular articulations, represents that bone.

The metatarsals are directed obliquely backwards as well as outwards, as in Tachyglossus and Platypus.

The following results may be derived from the preceding statements: (1) The relations and number of the bones of the posterior foot are those of the Mammalia much more than those of the Reptilia. (2) The relations of the astragalus and calcaneum to each other are as in the Monotreme *Platypus anatinus*. (3) The articulation of the fibula with both calcaneum and astragalus is as in the Monotreme order of mammals. (4) The separate articulation of the anterior part of the astragalus with the tibia is as in the same order. (5) The presence of a facet for an articulation of a spur is as in the same order. (6) The posterior-exterior direction of the digits is as in the known species of Monotremata.

Thus the characters of the posterior foot of the Pelycosauria confirm the

evidences of Monotreme affinity observed by Professor Owen and myself in the bones of the legs, especially of the anterior leg. It remains a fact that with this resemblance in the leg there is a general adherence to the reptilian type in the structure of the skull. But this adherence is not so exclusive as has been supposed, as I will now endeavor to show.

THE STRUCTURE OF THE COLUMELLA AURIS IN CLEPSYDROPS LEPTOCEPHALUS.—As already briefly described above, this element is bifurcate at the proximal extremity. The shorter expanded extremity is the stapes proper. The oblique perforation of its base is a character which has not been hitherto observed in any reptile, not even in the allied form Hatteria (Huxley). If, as is probable, the perforation is homologous with the foramen of the mammalian stapes, we have here another point of resemblance to this class. The longer proximal branch of the columella has only half the width of the stapedial portion, and its long axis makes an obtuse angle with that of the latter. It is perhaps the ossified suprastapedial cartilage of Huxley, which that author states (Anatomy of Vertebrated Animals, p. 77) is not ossified in any of the living Sauropsida. Huxley supposes this cartilage to be the homologue of the incus, and remarks * that in a young Mammalian fœtus "it appears exactly as if the incus were the proximal end of the cartilage of the first visceral arch." The columella now described resembles a rib, of which the suprastapedial process resembles the head, and the stapes the tubercle. If this process be the incus, the stapes is shortened as in the majority of Mammalia, unless the primitive suture between the two be longitudinal. The form and position of the true stapes give support to the view of Salensky, that it is not part of a true visceral arch, but is developed in the connective tissue surrounding the mandibular artery. We see that in this Pelycosaurian it is not the proximal part of the arch, and surrounds the mandibular artery. The columella is divided into at least two distinct elements. This is clearly indicated by its abrupt truncation distally by a rough sutural surface. If there is but one bone distad to the stapes, it is homologous with the cartilage, which has been shown by Peters † to be distinct in Hatteria, crocodiles and various lizards. It is the triangular ligament of Cuvier. If the suprastapedial be incus, this element is malleus; and it is usually identified as such by the older anatomists. In this structure we have evidence that the hypothesis that the articular and quadrate bones are homologous with the ossicula auditus is incorrect. The Pelycosauria will probably come under the head of "Sauropsides malleoferes" of Albrecht. We have here an approximation to the Mammalia in two points: (1) The perforation of the head of the stapes; (2) and the ossification of the incus, which (3) is distinct from the malleus, thus furnishing homologues of the principal ossicles of the ear. It

* Proceedings Zool. Society, London, 1869, p. 391.

† Monatsberichte der Academie Sciences, Berlin 1868 (p. 592)—1870.

is unnecessary to observe however, that this part of the skeleton does not resemble the corresponding part in the known Monotremes.

Structure of the quadrate bone in the genus Clepsydrops.—The quadrate bone in *Clepsydrops leptocephalus* Cope, already described, is of highly interesting form. It consists of two portions, a vertical and a transverse, the latter much longer than the former. The vertical portion is wedge-shaped with the base fashioned into the condyle for the mandibular ramus. Its posterior face to the apex, is articulated with the large squamosal, which rises towards the pariëtal bone. The distal part of the quadrate is grooved anteriorly, and each edge sends a process forwards. The internal is short, and articulates with the pterygoid. The external is the long horizontal part of the bone already mentioned. It is compressed, and at the end is acuminate. Although the malar bone is out of place in the specimen described, examination of the skull of the *Clepsydrops natalis*, where it is preserved in position, shows that this horizontal ramus of the quadrate is nothing more than the zygomatic process of the squamosal bone of the Mammalia, forming with the malar bone the zygomatic arch. *In the Pelycosauria there is but one posterior lateral arch*, as is demonstrated by many specimens; hence, we have here a reptile with a zygomatic arch attached to the distal extremity of the quadrate bone.

Important results follow this determination. We have seen that, with Peters, we need no longer look to the auricular chain of ossicles, and especially to the incus, to find the homologue of the os quadratum of the Vertebrata below the Mammalia. According to Albrecht *the os quadratum is the homologue of the zygomatic portion of the squamosal bone.* If this be true, in the process of specialization of the reptiles, the anterior or zygomatic portion of the quadrate has been lost or separated as a quadratojugal bone, and the condylar portion extended, until it has reached the extreme length we observe in snakes. This determination of the character of the quadrate bone in the Theromorphous Reptilia is confirmatory of the theory broached by Albrecht.* Among many propositions novel to the science of osteology, none has been more unexpected than his assertion that the quadrate bone is the homologue of the zygomatic and glenoid portion of the squamosal bone of Mammalia. This is in contradiction to the view held by many comparative anatomists from the day of Reichert to the present time.

I made a study of these arches several years ago, which is published in the Proceedings of the American Association Adv. Science, Vol. xix, p. 18. Accepting the prevailing view that the quadrate bone is one of the auditory ossicles, I naturally homologized the superior arch of the reptilian skull, which articulates with the squamosal proper, with the zygomatic arch, and looked upon the quadratojugal arch as an additional structure, connected with the peculiar development of the supposed incus.

* Sur la valeur morphologique de l'articulation mandibulaire et des osselets de l'oreille, etc, Bruxelles, Mayolez, 1883.

Should Albrecht's determination of the homology of the quadrate bone prove to be correct, the quadratojugal arch is the zygomatic, and the superior arch becomes the accessory one. This being admitted, the Lacertilia cannot be said to have a zygomatic arch, and the Theromorpha do not possess their postorbito-squamosal arch; the diversity between the two orders being thus greater than has been supposed.

The articulation of the ribs in Embolophorus.—The ribs of the Theromorpha are two-headed. While the tubercular articulation has the usual position at the extremity of the diapophysis, the capitular is not distinctly, or is but partially indicated, on the anterior edge of the centrum, in Clepsydrops and Dimetrodon. In Embolophorus, as I showed in 1869, the capitular articulation is distinctly to the intercentrum. A second and larger species of that genus, recently come to hand, displays this character in a striking degree, since the intercentrum possesses on each side a short process with a concave articular facet for the head of the ribs. From the slight corresponding contact with the intercentrum seen in Dimetrodon and other genera, there can be little doubt that this is the true homology of the ribs in the order Theromorpha.

The consequence follows from this determination, that the ribs of this order are intercentral and not central elements, and that they do not therefore belong to the true vertebræ, thus agreeing with the chevron bones, with which they are homologous.

It is also true that this type of rib-articulation *approximates closely that of the Mammalia*, where the capitular articulation is in a fossa excavated from two adjacent vertebræ. This is what would result if the intercentrum were removed from a Theromorph reptile, and the head of the rib allowed to rest in the fissure between the centra left by the removal. It is well known that the double rib articulation of the other reptilian orders which possess it, viz.: Ichthyopterygia, Crocodilia, Dinosauria and Pterosauria, and in the birds, is different, the capitular connection being below the tubercular, on the centrum. Whether the capitular articulations and the ribs in these orders are homologous with those of the Theromorpha, remains to be ascertained,

The origin of the Mammalia.—The relation of the characters of the Pelycosaurian suborder of the Theromorpha to those of the Mammalia may now be seen to be very important. I give a synopsis of the characters of these divisions parallel with those of the Batrachia contemporary with them, in order to give a clear idea of the reasons for believing that *the Mammalia are the descendants of the Pelycosauria.*

The following table shows that the Mammalia agree with the Batrachia in two and part of another character; with the Pelycosauria in six characters, and with other Reptilia in two characters. The Pelycosauria agree with the Batrachia in two and in parts of two other characters, and with other Reptilia in three characters, two of which (Nos. 2 and 3) are of prime importance. Of the characters in which the Pelycosauria agree

	Batrachia.	Pelycosauria.	Other Reptilia.	Mammalia.
1. Basicranial axis,	Unossified and with a parasphenoid.	Ossified; no parasphenoid.	Ossified; no parasphenoid.	Ossified; no parasphenoid.
2. Occipital condyle,	Two.	One.	One.	Two.
3. Quadrate bone,	Separate.	Separate.	Separate.	"Coössified with squamosal."—(Albrecht.)
4. Postorbitosquamosal arch,	Present (in Permian forms).	Wanting.	Present (generally).	Wanting.
5. Coracoid bone,	Small, coössified.	Small, coössified.	Large, distinct.	Small, coössified.
6. Ribs,	Diapophysial.	Intercentral.	Diapophysial and central (in position).	Intercentral.
7. Pelvis,	Without obturator foramen.	Without obturator foramen.	With obturator foramen.	With obturator foramen.
8. Posterior foot,	Intermedium, tibiale, fibulare and centrale distinct.	Tibiale, fibulare and centrale distinct; intermedium united with tibiale.	Intermedium, and centrale not distinct; tibiale and fibulare generally not distinct.	Tibiale, fibulare and centrale distinct; intermedium united with tibiale.
9. Humerus,	With condyles.	With condyles and epicondylar foramen.	No epicondylar foramen rarely condyles.;	Condyles; frequently epicondylar foramen.

with the Mammalia, two are of first class importance (Nos. 1 and 5); three are of great but unascertained degree of importance (Nos. 4, 6 and 8), and one (No. 9) is of less importance. The two characters (Nos. 2 and 5) in which the Mammalia agree with the Batrachia, are of high importance, but one of them is also a point in which the Pelycosauria agree with both (structure of the coracoid bone, No. 5). There is but one character, the distinctness of the quadrate bone, in which the Batrachia agree with the Reptilia in general.

The preceding comparison renders it extremely probable that the Mammalia are descended from the Pelycosaurian Reptilia. The usual definitions have been invalidated, excepting that of the occipital condyles, but even this is not so absolute a character as has been supposed. In the gecko lizard, Uroplates, the occipital condyle is represented by the exoccipital pieces only, the basioccipital element being omitted nearly as in the Mammalia. Professors Huxley and Parker have declared it as most probable that the true ancestor of the Mammalia have been the Batrachia. It is evident that the Pelycosauria are in various respects the most Batrachian of the Reptilia, for they agree with them in three and parts of two other characters of the nine above enumerated. One of the latter is the structure of the posterior foot, which displays much less modification from the Batrachian type than that of the ordinary Reptilia.

The first evidence of the resemblance of the Pelycosauria to the Mammalia was empirical and not conclusive. This consisted in the characters derived from the long bones of the limbs. Professor Owen first called attention to this resemblance in the genus Cynodraco, which is a Theromorph reptile. I next pointed out corresponding peculiarities in the humeri of the American Theromorphs. I subsequently showed the resemblance between the pelvis of the Pelycosaur division, and that of the Monotremata. This was followed by a demonstration of the resemblance between the coracoid of the Pelycosauria and the Mammalia of the Monotrematous order, especially the family of the Platypodidæ. The present article now adds that the structure of the posterior foot approaches near to that of the Monotremata; and that the os quadratum and the ribs are essentially like the corresponding parts in all the Mammalia. The last three points are essential and fundamental. The three great distinctions between the Mammalia and Reptilia in the skeleton are: (1) in the quadrate bone; (2) in the coracoid bone, and (3) in the occipital condyle. Of these the last only now remains, and this is weakened by the presence of the Mammalian type in the geckotian lizard already referred to. The only interruption in the series which has not yet been overcome is in the columella auris. No reptile is yet known where that element is divided into incus, orbicularis, and stapes, as in the Mammalia and some Batrachia (according to Albrecht). Of course the above comparison with the Monotremata considers the latter order in its proper ordinal definitions, and not in its special subordinate modifications now existing, the Platytidæ and Tachyglossidæ. Montremata dentition like that of the known Jurassic and Triassic Mammalia will doubtless yet be discovered in beds of those ages.

As this paper goes to press, the interesting announcement made at the meeting of the British Association for the advancement of science at Montreal may be referred to. Mr. Caldwell, the holder of the Balfour scholarship, telegraphs that he has discovered that the *Platypus anatinus* is oviparous, and that the egg is meroblastic. This confirms the hypothesis of descent from reptilian ancestors rather than Batrachian. Haeckel gives the segmentation as meroblastic, Studien zur Gastræa Theorie, Jena, 1877, p. 65.

Note on the Tarsus.—I am just in receipt of an MS. from Dr. Baur, of New Haven, in which he presents an identification of the "internal navicular" bone of some rodents, and which probably existed in the ungulate genera Pantolambda and Bathmodon. He identifies it with the tibiale, and denies that the astragalus includes that element, but that it consists wholly of the intermedium. This identification will also apply, though Dr. Baur in his manuscript does not make it, to the element which supports the spur in the known Monotremata. It will also explain the nature of the element which occupies the same position in the foot of the Pelycosauria above described. The arrangement in this order of reptiles confirms the conclusion reached by Dr. Baur, since the questionable element is here in direct contact with the tibial facet of the astragalus.

Note on Phylogeny of the Vertebrata.—As my researches have now, as I believe, disclosed the ancestry of the Mammals,* the birds,† the reptiles, and the true fishes,‡ or Hyopomata, I give the following phylogentic diagram illustrating the same. This will only include the leading divisions. The special phylogenies of the Batrachia‖ and Reptilia,§ and some of the Mammalia¶ have been already given.

The Mammalia have been traced to the Theromorphous reptiles through the Monotremata. The birds, some of them at least, appear to have been derived from the Dinosaurian reptiles. The Reptilia in their primary representative order, the Theromorpha, have been probably derived from the Rhachitomous Batrachia. The Batrachia have originated from the subclass of fishes, the Dipnoi,‡ though not from any known form. I have shown that the true fishes or Hyopomata have descended from an order of sharks,‡ the Ichthyotomi, which possess characters of the Dipnoi also. The origin of the sharks remains entirely obscure, as does also that of the Marsipobranchi. Dohrn** believes the latter class to have acquired its

* American Naturalist 1884, p. 1136.

† Proceedings Academy Philadelphia, 1867, 234.

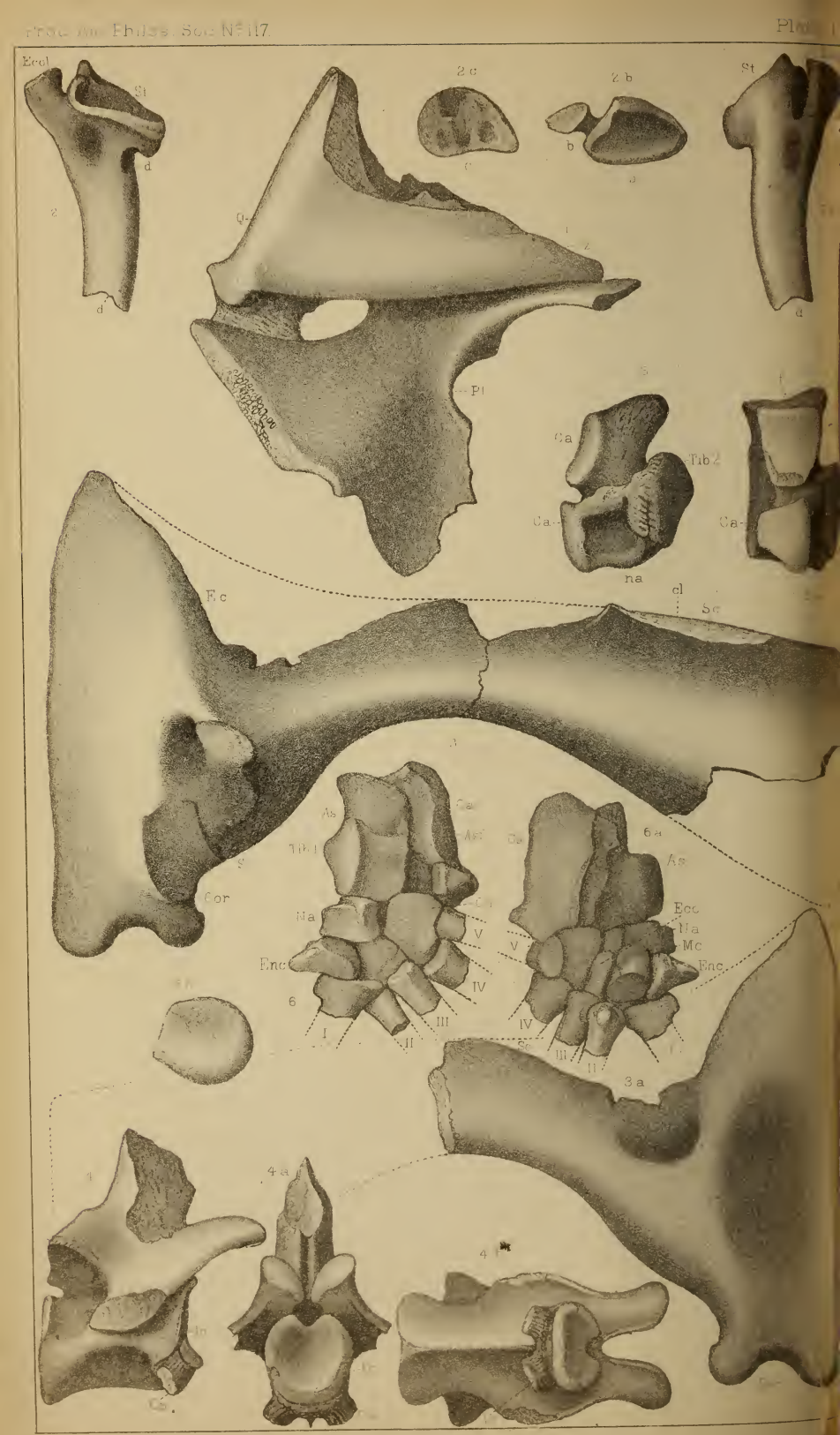
‡ Proceedings American Philosophical Society, 1884, p. 585.

‖ American Naturalist, 1884, p. 27,

§ Proceedings American Association for the Advancement of Science, xix, 1871, 253.

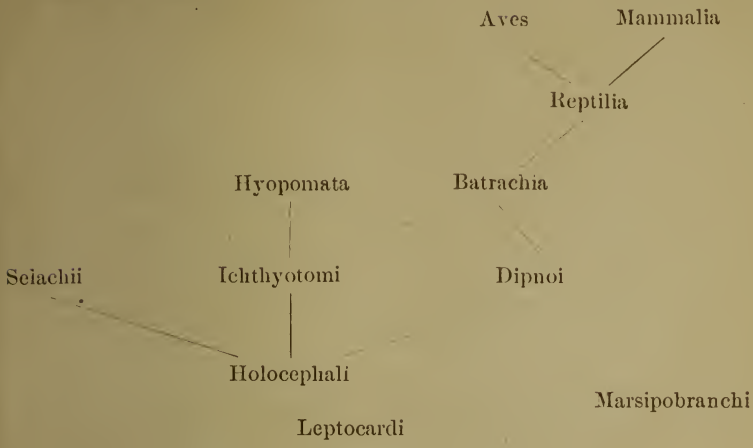
¶ Proceedings American Philosophical Society, 1882, 447; American Naturalist, 1884, p. 261 and 1121. Report U. S. Geol. Survey W. of 100th Mer., G. M. Wheeler, 1877, iv, ii, p. 282.

** Der Ursprung der Wirbelthiere u. d. Princip des Functionwechsels, von Anton Dohrn, Leipsic, 1875, p. 32.



HONES OF TRINCUSPURIA

present character by a process of degeneration. The origin of the Vertebrata is as yet entirely unknown, Kowalevsky deriving them from the Tunicata, and Semper from the Annelida.



EXPLANATION OF PLATE.

Fig. 1. *Clepsydrops leptocephalus* Cope, right quadrate bone (Q) with condyle and zygomatic process (*z*) from the right, or external side. *Pt*, pterygoid bone of same side displaced so as to be in plane of quadrate, and to be seen from inferior side. One-half natural size.

Fig. 2. Columella auris of the individual of *Clepsydrops leptocephalus* represented in fig. 1; internal side. Fig. 2*a* external side; 2*b* proximal extremity; 2*c* distal extremity; *s*, head of stapes; Ecol. epicolumella; *d*, distal articular surface, especially represented in fig. 2*c*. All figures are half natural size, excepting 2*c*, which is natural size.

Fig. 3. Left half scapular arch of a Pelycosaurian, less clavicle and episternum, one-half natural size. *sc*, scapula; *cl*, facet for clavicle; *cor*, coracoid; *ec*, epicoracoid; *s*, open suture between coracoid and epicoracoid, indicating the immaturity of the animal.

Fig. 4. Dorsal vertebra of a species of Embolophorus, one-half natural size; right side; *a*, from front; *b*, from below; *ic*, intercentrum; *ca*, capitular rib articulation.

Fig. 5. Astragalus of individual figured in fig. 4, one-half natural size; from below. *ca*, *ca*, facets for calcaneum; *na*, do. for navicular; *tib*, 2, do. for bone of spur, or os tibiale. 5*a*, same bone from external or calcaneal border; *f*, fibular facet. 5*b*, same bone, proximal or fibular extremity.

Fig. 6. Left posterior foot of *Clepsydrops natalis* Cope, superior side, and 6*a*, inferior (plantar) side, two-thirds natural size. *as*, astragalus; *ca*, calcaneum; *na*, navicular bone; *cu*, cuboid; *euc*, *mc* and *ecc*, entocuneïform, mesocuneïform and ectocuneïform bones, respectively. I, II, III, IV, V, metatarsals. *Tib* 1, Probable tibial facet. In this specimen the calcaneum is displaced; being turned backwards, so as to present its two astragalar facets (*asf*) anteriorly.

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THE AMBLYPODA.

By E. D. COPE.

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THE AMBLYPODA.

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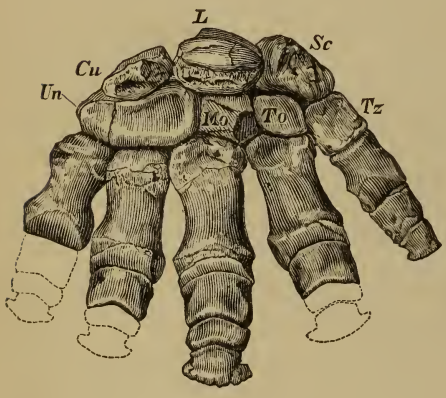
THE Amblypoda is that order of hoofed mammals in which the internal bones of the carpus are in linear series, the magnum supporting a part of the lunar only, and not reaching the scaphoid; and in which the tarsal bones are interlocked, as in the later types of hoofed Mammalia; that is, the cuboid bone articulates extensively with the astragalus, as well as with the calcaneum (see Figs. 1–2).



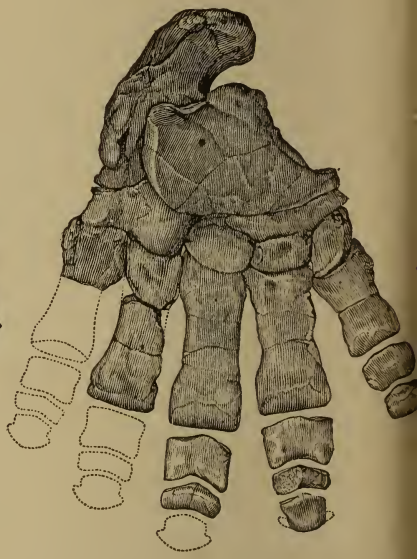


FIG. 1.—Right manus of Coryphodon. Original, from Proc. Amer. Philos. Society, 1882, p. 441. *Sc*, scaphoid; *L*, lunar; *Cu*, cuneïform (imperfect); *Tz*, trapezium; *To*, trapezoides; *Mo*, magnum (face broken); *Un*, unciform. From a New Mexican specimen. See Report U. S. G. G. Survey W. of 100th mer., IV, pl. LXI.

FIG. 2.—Right posterior foot of a species of Coryphodon from New Mexico, one-half nat. size. From Report Expl. W. of 100th mer., G. M. Wheeler, IV, pl. LIX.

Various other characters are associated with these, some of which may be coëxtensive with them, and therefore to be regarded as characters of the order. Thus all the known species have five toes on all the feet, and a flat astragalus without trace of groove. The unciform bone is extensively in contact with the lunar, as in the Diplarthra. The hemispheres of the brain are of singularly small size, and are separated from the olfactory lobes and from the cerebellum by their crura. The feet are always short and plantigrade.

Ordinal characters of wider significance are seen in the pres-

ence of a postglenoid process; the presence of enamel on the teeth, and the absence of any teeth growing from persistent pulps. The superior molar teeth are constructed on the tritubercular type.

Mammalia presenting the above combination of characters first appear in the Puerco Eocene epoch, and continue through the Wasatch and Bridger epochs, and then disappear. They have not been found in later deposits. The Puerco species are smallest in dimensions, while those of the Bridger epoch are the largest of Eocene Mammalia, equaling in the size of some of their bones the largest of living terrestrial Mammalia. Besides their great size the species of the Bridger epoch prove the ancient exuberance of their growth-energy in the development of extraordinary processes and horns on the head and large and formidable canine teeth.

Three suborders represent this order. Each one is confined to a distinct horizon of the Eocene period, with one doubtful exception. The characters are as follows:

Astragalus with a head; a third trochanter of femur; superior incisors.. *Taligrada.*
No head of astragalus; a third trochanter; superior incisors..... *Pantodonta.*
No head of astragalus, nor third trochanter, nor superior incisors..... *Dinocerata.*

The Taligrada only occur in the Puerco epoch, the Pantodonta are confined to the Wasatch, and the Dinocerata belong to the Bridger epoch, one species having been found extending downwards into the Wasatch, unless there be some error.[1]

The Taligrada.

The Taligrada are represented by one family, and one genus, Pantolambda Cope.[2] This form is interesting on various accounts. It furnishes the only known example of a tritubercular selenodont superior molar dentition. That is, each of the three cusps of which the crown of the superior molar is composed, is a well-formed V (Fig. 3 *a*). We shall see later on, that this form explains the origin of the peculiar molars of some of the Pantodonta. Its astragalus is of remarkable form, which is intermediate between that presented by the other members of the order, and the diplarthrous ungulates, as for instance, the rhinoceroses (Fig. 3, fig. *d d' d''*). It has the flat tibial face characteristic of all the Puerco mammals, and of many of those of the Wasatch

[1] This is the *Bathyopsis fissidens* Cope.

[2] See NATURALIST, 1883, p. 406.

epoch. The inferior molars are much like those of Coryphodon, but differ in certain details. The premolars are even more like those of that genus (Fig. 6). The humerus differs from that of all other members of the order in having an epicondylar foramen (Fig. 5 *a*). In this respect, and in its large internal epicondyle, the form is like that of some Creodonta. The ilium differs remarkably from that of the other genera of the order in its narrow form, with flattened

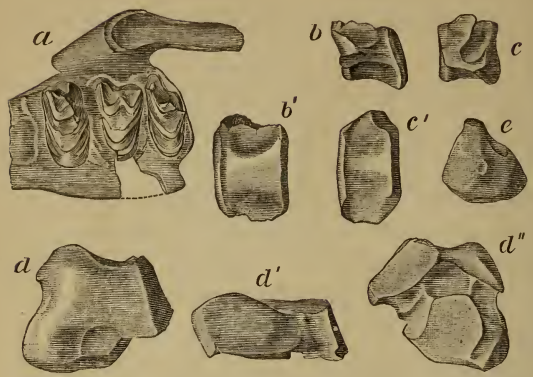


FIG. 3.—Bones and teeth of *Pantolambda bathmodon* Cope, two-thirds nat. size. From the Puerco beds of New Mexico. Fig. *a*, part of maxillary and malar bones from below, showing true molars, all somewhat broken. Figs. *b* and *c*, cervical vertebræ, left side; *b'* and *c'*, do. from below. Fig. *d*, astragalus from above; *d''*, from front, showing facet for cuboid; *d'''*, from below; *e*, navicular bone from below. Original, from Report U. S. Geol. Survey Terrs., F. V. Hayden.

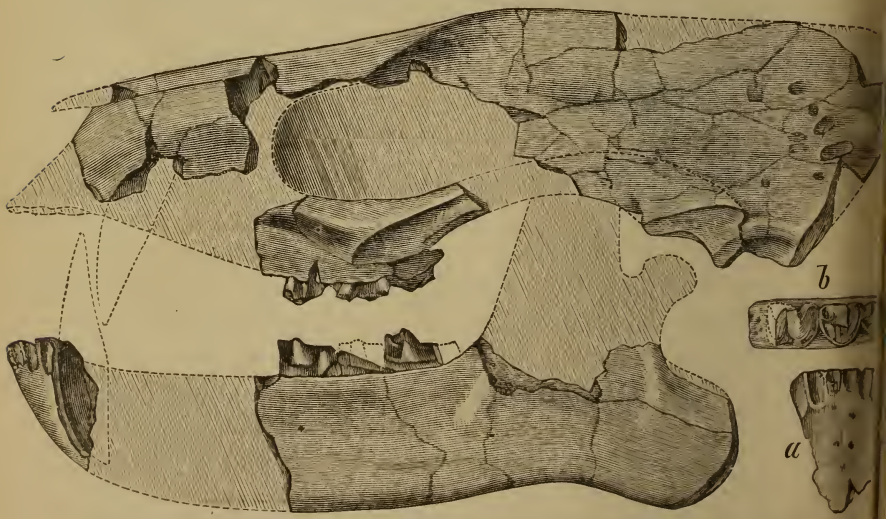


FIG. 4.—*Pantolambda bathmodon* Cope, skull, two-thirds nat. size. From the Puerco beds of New Mexico; individual represented in figs. 3 and 5. Fig. *a*, symphysis mandibuli from front. Fig. *b*, last two premolars and first true molar of inferior series from above, of a second individual. Original, from Vol. III Report U. S. Geol. Survey of Terrs., F. V. Hayden in charge.

triangular section, as is seen in various Rodentia. It approximates the Condylarthra in this respect also.

In all respects Pantolambda presents primitive characters. The V shape of its molar tubercles only presents us with the highest known modification of the primitive tritubercular molar,[1] excepting those which succeeded it in time in the remaining suborders of the Amblypoda.

Of the genus Pantolambda two species have been discovered, both by Mr. David Baldwin, in New Mexico. The smaller of these, the *P. bathmodon* Cope (Fig. 4) is about the size of a coyote, the larger, *P. cavirictus* Cope (Fig. 6) is as large as a South American tapir, or nearly equal to the smallest species of Coryphodon. The ungues of the *P. bathmodon* which have been found (Fig. 5 *c*) are narrower than those of the *P. cavirictus*, but they may differ in proportions on different digits as in the species of Phenacodus. Both species are furnished with formidable canine teeth, but they are of normal form, and do not present any of the peculiarities of those of the Pantodonta or Dinocerata. In the lower jaw of the *P. cavirictus* (Fig. 6) they are somewhat recurved, furnishing a formidable seizing and holding weapon. The lower edge of the mandibular

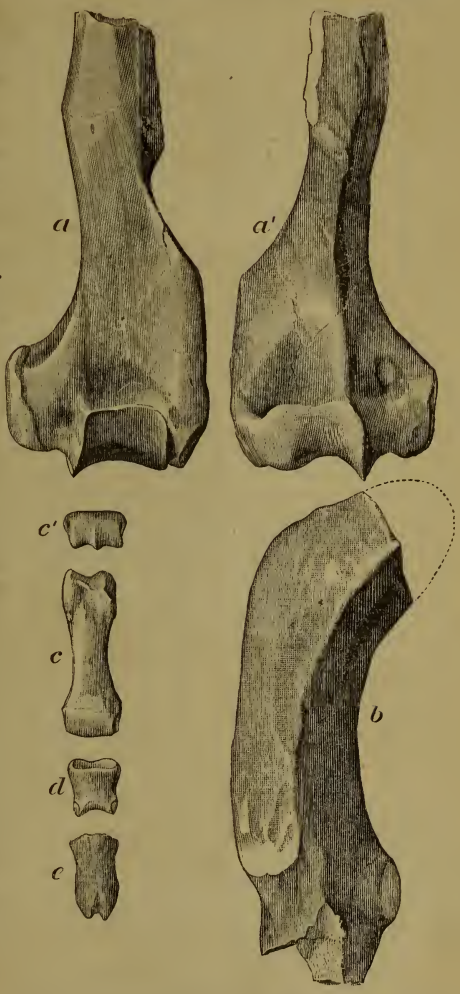


FIG. 5.—*Pantolambda bathmodon* Cope, bones of individual represented in figs. 3 and 4, two-thirds nat. size. Fig. *a*, distal half of humerus, posterior side; *a'*, anterior side. Fig. *b*, ilium from inner side. Fig. *c*, metapodial bone from front; *c'*, distal view; *d*, phalange; *e*, unguis. Original.

[1] On this subject see Proceeds. Amer. Philos. Soc., 1883, p. 324.

ramus is prominent anteriorly, leaving a concavity of the lateral face posterior to the root of the canine. This resembles a good deal what is seen in the cat-like genus Nimravus and allies, which

FIG. 6.—*Pantolambda cavirictus* Cope, mandibular rami, two thirds natural size. Fig. *a*, right ramus for outer side. Fig. *b*, left ramus from above. From Puerco bed. Original, from Vol. III Report U. S. Geol. Survey Terrs., F. V.

are probably the ancestors of the saber-tooth tigers. The corresponding form in Pantolambda in the same way foreshadows the great development of mandibular flange, and of the superior canine, seen in the Dinoceratous group of this order.

The homologies of the parts of the teeth of the different genera of the Amblypoda are not determined without considerable study. The greatest difficulties are presented by the superior molars, and in order to understand them it is necessary to study the inferior molars first.

If we compare the inferior molars of the *Pantolambda cavirictus* with those of the *Bathyopsis fissidens* (Fig. 7) (one of the Dinocerata) the following modifications will be observed: (1) The two limbs of the anterior V in the true molar of the former are represented in the latter by a single crest with two appressed apices at the inner extremity. These apices represent those of the two limbs of the V. (2) The posterior limb of the posterior V is much diminished in elevation, and does not join its anterior limb at the apex on the external side of the crown. If we now examine the corresponding parts of another Dinoceratous Amblypod, a species referred by Mr. Osborn to the genus Loxolophodon (Fig. 8), we find the process carried still further. The crown has only two crests which approach each other but do not join at the apex on the inner side. The

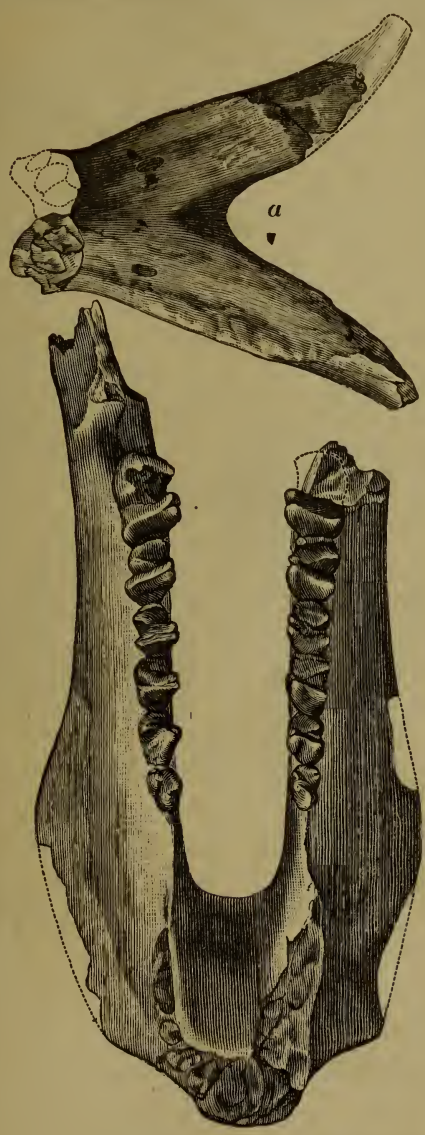


FIG. 7.—*Bathyopsis fissidens* Cope (one of the Dinocerata), mandible anterior to the coronoid process; incisors and canines and first premolar lost from both sides, two-thirds nat. size, from above; *a*, from front. Original, from Wind River (? Bridger) of Wyoming. From Vol. III Report U. S. Geol. Survey Terrs., F. V. Hayden.

posterior limb of the posterior V has disappeared, and a small

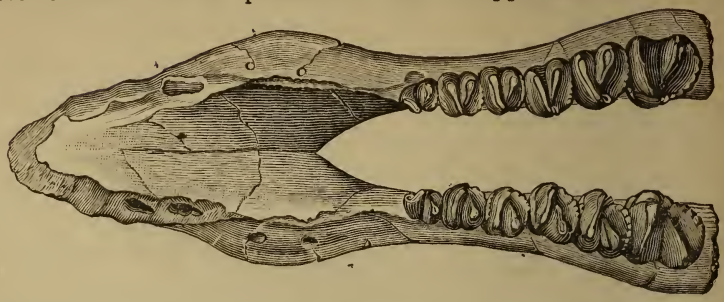


FIG. 8.—Loxolophodon sp., mandible anterior to coronoid process, one-fourth nat. size; from Bridger beds of Wyoming. From Osborn, memoir on Loxolophodon and Uintatherium.

cusp represents the posterior crest of the anterior V.

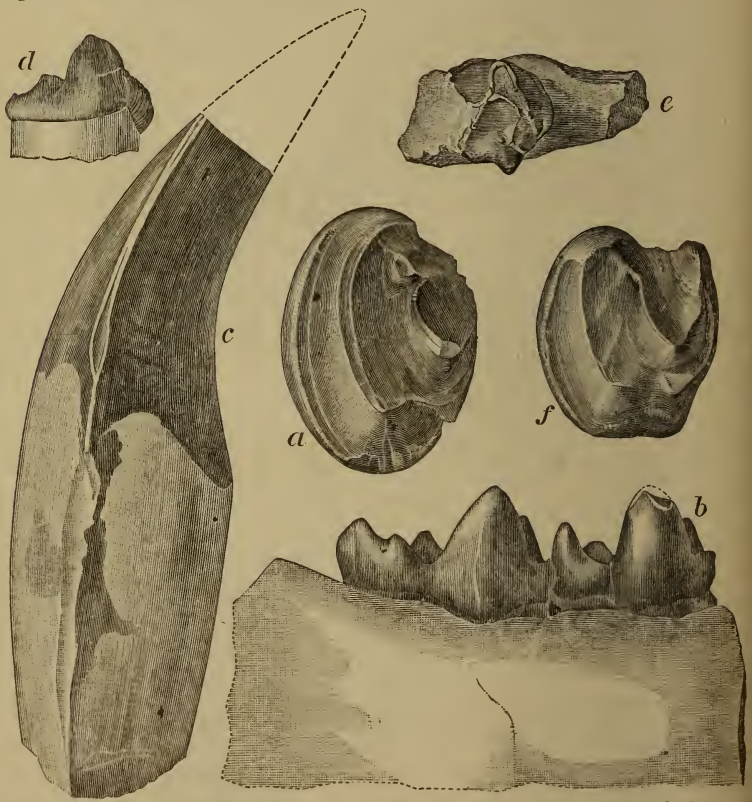


FIG. 9.—Teeth of Pantodonta, two-thirds nat. size. Figs. *a–d*, *Coryphodon anax* Cope; from the Wasatch beds of Wyoming. Original, from Vol. III Report U. S. Geol. Surv. Terrs. Fig. *e*, *Coryphodon cuspidatus* Cope, last inferior molar from above, anterior V broken; from New Mexico. Report U. S. G. G. Survey W. of 100th mer., G. M. Wheeler, original. Fig. *f*, last superior molar of *Manteodon quadratus* Cope, from below; from Wyoming. Original, from Vol. III Report U. S. Geol. Surv. Terrs., F. V. Hayden in charge.

Let us now compare the superior molars of Pantolambda (Fig. 3) with those of Coryphodon (Fig. 9 *a*). The two external Vs of the former are represented in the latter by a cusp and a partial V, which form an oblique ridge on the external half of the posterior side of the tooth. This arrangement is already imitated on the last molar of Pantolambda, where one of the Vs has disappeared, and the one that remains is very oblique.

The second V preserves its form better in the superior molar of *Manteodon quadratus* (Fig. 9 *f*); while in the genus Metalophodon Cope, it is reduced to a cusp, forming the inner extremity of a transverse crest. (A figure of this genus will be given in the next number of the NATURALIST.) The interior V of Pantolambda is represented by a corresponding angle at the inner side of the crown in Coryphodon (Fig. 9 *a*), and the two ridges which connect it with the external base of the crown are well marked. Besides these there is developed on the anterior side of the base a strong cingulum. This is wanting on the posterior side, but is present in a feeble form in Pantolambda (Fig. 3). I have sometimes called these the superior and inferior anterior cingula respectively. In Coryphodon the posterior superior cingulum is unsymmetrically bulged near its interior end, and in Manteodon it develops a cusp at this point, the crown thus becoming quadritubercular (Fig. 9 *f*).

FIG. 10.—Dinocerata teeth, one-fourth nat. size. Upper figures superior molars of *Uintatherium leidianum*, one-fourth nat. size. Lower figure, inferior molars of jaw of Loxolophodon represented in fig. 8. From Osborn, memoir on Uintatherium and Loxolophodon.

If we now compare these teeth with those of Uintatherium (Fig. 10) we have little difficulty in determining the presence of the two anterior cingula. The difficulty is to ascertain the homology of the posterior transverse crest. It is difficult to see in it the two external Vs of Pantolambda confluent into a simple ridge, yet such it seems to be. This will be especially clear on comparison with the figure of Metalophodon. One is tempted to compare it with the posterier superior cingulum of Coryphodon, but the frequent presence

of a cusp posterior to its internal extremity in the Dinocerata presents a further obstacle to such a determination. This cusp is probably homologous with the posterior internal tubercle of Man-

FIG. 11.—Last three temporary molars, and first true molar partly protruded, of a Coryphodon from New Mexico, nat. size. Original, from Report U. S. G. G. Survey W. of 100th mer., G. M. Wheeler, Vol. IV, pt. II.

teodon (Fig. 9*f*), and is, therefore, the posterior internal of the quadrituberculate molar type. The internal extremity of the posterior crest of the crown in the Dinocerata cannot, therefore, be that cusp, and that ridge is not a posterior transverse crest, such as is present in most Perissodactyla.

It is interesting to observe that the fourth superior deciduous molar in Coryphodon (Fig. 11) has essentially the same structure as the true permanent molar of Pantolambda (Fig. 3).

The origin of the Amblypoda has not yet been traced. What was known on this point, as well as on the question of the descendants of the order, was stated as follows in my paper on the classification of the ungulate Mammalia, published in 1882:[1]

"As regards the inner part of the manus, I know of no genus which presents a type of carpus intermediate between that of the Taxeopoda and Amblypoda on the one hand, and the Perissodactyla and Artiodactyla on the other. Such will, however, probably be discovered. But the earliest Perissodactyla, as for instance Hyracotherium, Hyrachyus and Triplopus, possess the carpus of the later forms, Rhinoceros and Tapirus. The order Amblypoda occupies an interesting position between the two groups, for while it has the carpus of the primitive type, it has the tarsus of the later orders. The bones of the tarsus alternate, thus showing a decided advance on the Taxeopoda. This order is then less primitive than the latter, although in the form of its astragalus it no doubt retains some primitive peculiarities which none of the

[1]Palæontological Bulletin No. 35. Proceedings Amer. Philosoph. Society, 1882, p. 445.

known Taxeopoda possess. I refer to the absence of trochlea, a character which will yet be discovered in the Taxeopoda, I have no doubt.

"The Taxeopoda approach remarkably near the Bunotheria, and the unguiculate and ungulate orders are brought into the closest approximation in these representatives. In fact I know of nothing to distinguish the Condylarthra from the Mesodonta, but the ungulate and unguiculate characters of the two divisions. In the Creodonta this distinction is reduced to very small proportions, since the claws of Mesonyx are almost hoofs. Some of the genera of the Periptychidæ present resemblances to the Creodonta in their dentition also.

"The facts already adduced throw much light on the genealogy of the Ungulate Mammalia. The entire series has not yet been discovered, but we can with great probability supply the missing links. In 1874 I pointed[1] out the existence of a yet undiscovered type of Ungulata, which was ancestral to the Amblypoda, Proboscidea, Perissodactyla and Artiodactyla, indicating it by a star only in a genealogical table. This form was discovered in 1881, seven years later, in the Condylarthra. It was not until later[2] that I assumed that the Diplarthra are descendants of the Amblypoda, although not of either of the known orders, but of a theoretical division with bunodont teeth.[3] That such a group has existed is rendered extremely probable in view of the existence of the bunodont Proboscidea and Condylartha. That the Taxeopoda was the ancestor of this hypothetical group, as well as of the Proboscidea, is extremely probable. But here again neither of the suborders of this group represent exactly the ancestors of the known Amblypoda, which have an especially primitive form of the astragalus not found in the former. In the absence of an ankle joint the Amblypoda are more primitive than any other division of the Ungulata, and their ancestors are not likely to have been more specialized than they. It is probable that a third suborder of Taxeopoda has existed which had no trochlea of the astragalus, which I call provisionally by the name of Platyarthra.

"The preceding paragraphs were written in May, 1882. On

[1] Homologies and Origin of Teeth, etc., Journal Academy Nat. Science, Philada., 1874, p. 20.

[2] Report U. S. Geol. Survey W. of 100th mer., p. 582, 1877.

[3] This hypothetical suborder has been called Amblypoda Hyodonta.

my return home, September 1st, after an absence of three months, I find that various parts of the skeleton of Periptychus have reached my museum.[1] On examination I find that the astragalus of that genus fulfills the anticipation above expressed. *It is without trochlea*, and nearly resembles that of Elephas. As it agrees nearly with that of Phenacodus in other respects, I only separate it as a family from the Phenacodontidæ. One other type remains to be discovered which shall connect the Periptychidæ and the hypothetical Hyodonta, and that is a taxeopod without a head to the astragalus—unless, indeed, the 'Hyodonta' should prove to have such a head. I think the latter the less probable hypothesis, and hence retain the term Platyarthra for the hypothetical taxeopod without trochlea or head of the astragalus." This group as at first defined had been already discovered, but in the above paragraph I added another definition, endeavoring to preserve an apparently useless name.

The existence of Amblypoda Hyodonta is rendered almost certain by the discovery that the genus Pantolestes of the Wasatch epoch is an artiodactyle with tritubercular bunodont superior molars. The ancestral type of such a form must have been a tritubercular bunodont amblypod. Pantolambda is such a form with the tubercles modified into Vs. Moreover, such a type (Amblypoda Hyodonta) would be derived from a periptychid Taxeopod with but little modification of the latter. A distinct facetting of the astragalus for the cuboid bone, and *probably* a change of the carpus by an articulation of the unciform and lunar bones, would be all that would be necessary. The discovery of Pantolambda has increased the probability of such change having taken place in the hind foot, since *the astragalus is intermediate in form between those of Coryphodon and Periptychus.* This is particularly seen in the form of the head, which is not separated by a neck as in Periptychus, but is more prominent than in other Amblypoda (Fig. 3). Thus it is possible that Amblypoda Hyodonta will be found to have a short head of the astragalus, contrary to my supposition above expressed. The headless astragulas of other Amblypoda and of Proboscidea is perhaps a derivative and not a primitive character.

The following diagram gives expression to these views as to the phylogeny of the ungulates. It is the same that I published

[1] See NATURALIST for August, 1884, for figures.

in 1882 in the paper above quoted, modified so as to be more intelligible:

(*To be continued.*)

THE AMBLYPODA.

BY E. D. COPE.

(Continued from page 1121, November number.)[2]

PANTODONTA.

THERE is known as yet but a single family of this suborder, the Coryphodontidæ. Its representatives have been found in the lower lacustrine Eocene beds in Europe and North America in considerable abundance. About twenty species have been described, of which three have been found in England and France, and the remainder in the Rocky Mountain region of North America. They form a curious and interesting group of hoofed Mammalia which did not survive the Lower Eocene time, except in their probable descendants, the Dinocerata. The characters of the suborder have already been given in the NATURALIST, page 1111.

Five genera of the Coryphodontidæ are known from dental characters. Two of these, Coryphodon and Bathmodon, are known in their skeletal structure, the first-named very thoroughly.

[2] The explanations of Fig. 7 (p. 1115) should read four-ninths nat. size; not two thirds nat. size.

Bathmodon is nearest to the genus Pantolambda in its foot structure. The astragalus has the same subquadrate outline (compare Figs. 3 *d* and 19 *a*), and possesses, as in that genus, a facet on its internal anterior angle, for another bone. This character is found among recent Mammalia in certain rodents, where a separate bone, the internal navicular, articulates with the internal extremity of the astragalus. This is probably the case in Bathmodon and Pantolambda, but the separate bone has not been found. In Coryphodon it is evidently wanting, as the astragalus terminates internally in a hook-like apex, which gives it a very peculiar appearance (Fig. 2). Until I traced this astragalus to Coryphodon in 1873,[1] the relation of this genus to the Dinocerata had not been suspected.

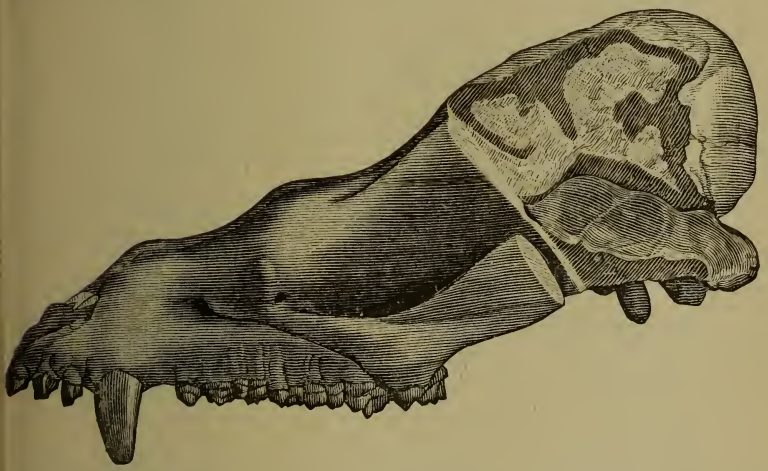


Fig. 12.—*Coryphodon elephantopus* Cope, skull from left side, the left half of the posterior part removed so as to display the small size of the brain cavity; two-ninths natural size. From Wasatch bed of New Mexico. Original.

The small size of the brain in this family is well displayed in the section of the skull of Coryphodon represented in Fig. 12, where the cavity it has occupied is exposed. Its relations to the skull are entirely different from those observed in all recent Mammalia excepting the elephants. As in them the diploë is represented by large air chambers.

The characters of the brain itself may be learned from Fig. 3. The exceedingly small size of the cerebral hemispheres at once arrests the attention, being much smaller than in the

[1] On the short-footed Ungulates of the Eocene of Wyoming. Proceedings Amer. Philosoph. Society.

cotemporary genus Phenacodus,[1] and agreeing with Uintatherium, which has been described by Marsh. There is no trace of sylvian fissure nor of convolutions. The middle brain is entirely exposed, and how much pertains to this and how much to the cerebellum remains uncertain. The anterior prolongation of the anterior pyramids is visible below the middle brain, as though the pons varolii were wanting (Fig. 13 *p*).

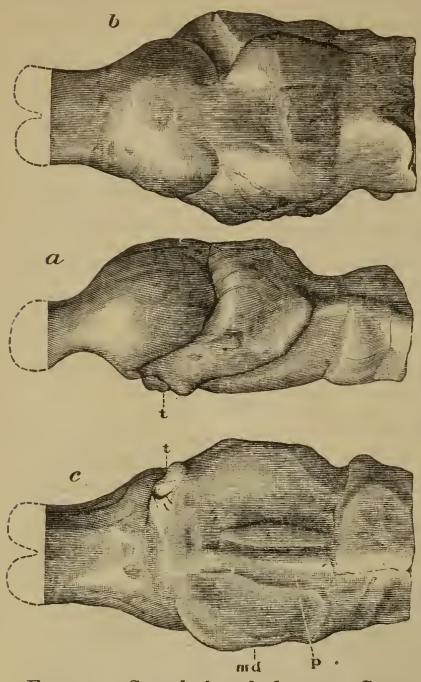


FIG. 13.—*Coryphodon elephantopus* Cope, cast of brain cavity seen in fig. 12, about one-third nat. size. Fig. *a*, left side; *b*, above; *c*, below. *t*, origin of trigeminus nerve; *p*, anterior pyramids. Original, from Proceed. Amer. Philos. Soc., 1877.

The characters of the long bones which are common to the members of this family may be observed in the *Bathmodon pachypus*, Figs. 14–15. The humerus shows the robust but not hooked tuberosities of the head, and the simple condyles. The radius shows the simple transverse head and the lateral distal facet. The femur (Fig. 15 *b*) has well developed trochanters, including the third, and a fossa ligamenti teris. The ilium (Fig. 15 *a*) like that of animals with a large belly, is much expanded, and has a wide peduncle. The pubis and ischium are light.

The five genera of Coryphodontidæ differ as follows:

I. Superior molars with two interior cusps.
All the superior molars with a well-marked external posterior V.....*Manteodon*.

II. Last superior molar with but one inner cusp or angle.

a. Last superior molar with posterior external cusp.
Anterior two molars with posterior external V.....*Ectacodon*.

aa. Last superior molar without external posterior cusp.

†Anterior two molars with posterior external V.
Astragalus transverse, with internal hook and no facet.....*Coryphodon*.
Astragalus subquadrate, with an internal facet and without internal hook, *Bathmodon*.

††First superior molar only, with posterior external V.....*Metalophodon*.

[1] See NATURALIST, 1884, p. 898, for figure.

The general relation of the teeth of these genera to those of other families of the order has been discussed (supra p. 1117). Their relation to each other may be understood by comparison of Fig. 9 *a* and *f* with Fig. 16. In the latter the anterior external V is marked a, and the posterior p. The posterior exterior angle of the latter is designated by the letter e. In Manteodon (Fig. 9 *f*) the posterior external V is observed to be well developed on the last superior molar. In Ectacodon (Fig. 16 *a*) its posterior edge is represented by an external cusp only (e), the rest of the border

FIG. 14.—*Bathmodon pachypus* Cope, bones of fore limb, one-fifth nat. size, from Wasatch beds of Wyoming. Fig. *a*, left humerus from behind; *a'*, proximal, *a''*, distal views. Fig. *b*, left radius from behind; *b'*, proximal, *b''*, distal views; *c*, pisiform bone. From Vol. III Report U. S. Geol, Survey, F. V. Hayden.

being absent. In Coryphodon this border is sometimes traceable (*C. anax*, Fig. 9 *a*) or is wanting. In Metalophodon it is entirely absent, and is represented by a conical projection of the posterior crest only (Fig. 16 *b* p). The posterior V of the second superior molar is distinct in all except Metalophodon (Fig. 16 *b* p), where it is represented by a crest only, as in the last molar of most of the species of Coryphodon. The succession is thus seen to consist of the gradual conversion of the external Vs into

transverse crests, a process which is consummated in the Dinocerata of the later Bridger epoch (see Fig. 10).

Of Bathmodon two species are known, *B. radians* (Fig. 18) and *B. pachypus* (Figs. 14, 15 and 19). The latter is the larger,

FIG. 15.—*Bathmodon pachypus* Cope, bones of individual figured in Fig. 14, one-fifth nat. size. Fig. *a*, left innominatum, somewhat distorted, internal view; *b*, left femur from behind. Original, from Wasatch beds of Wyoming.

equaling a large ox in dimensions. The crania of these species are unfortunately unknown. Both are from the Wasatch beds of Wyoming.

Of Ectacodon Cope, but one species, the *E. cinctus*, has been

discovered. It is only known from the superior molar teeth fig-

FIG. 16.—Superior molar series of Coryphodontidæ, two-thirds nat. size, from the Wasatch beds of Wyoming. Original. Fig. *a*, *Ectacodon cinctus* Cope. Fig. *b*. *Metalophodon tessis* Cope.

ured in Fig. 16 *a*. It is a large species, about equal to the *Bathmodon radians*.

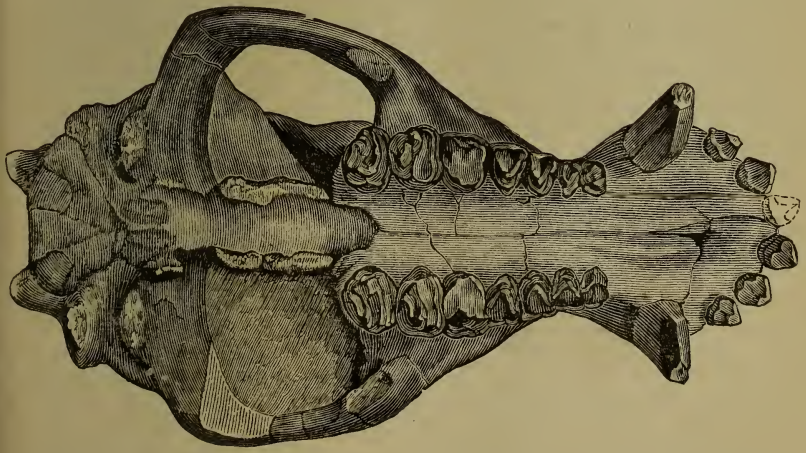


FIG. 17.—*Coryphodon elephantopus* Cope, skull, two-ninths nat. size, from below. Original, from Report G. M. Wheeler, U. S. G. G. Surv. W. of 100th mer., Vol. IV, pt. II.

The greater number of species of the family belong to Coryphodon. In this genus the temporal fossæ are lateral, as in modern ruminants, leaving a wide front with overhanging tem-

poral ridges (Figs. 20-21). The dental formula is the complete one of I. $\frac{3}{3}$; Pm. $\frac{4}{4}$; M. $\frac{3}{3}$. The superior canines are very powerful, and have three sides, giving a triangular section. In some of the species (*C. molestus*), this tooth is more compressed

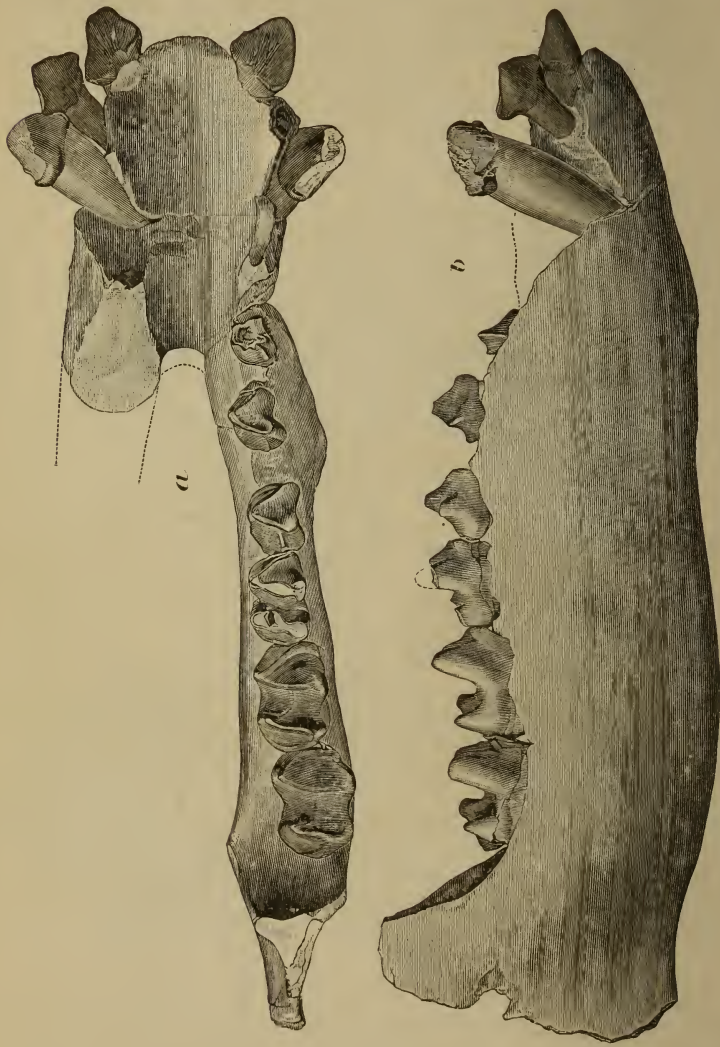


FIG. 18.—Lower jaw associated with the foot bones of *Bathmodon radians* Cope, from the Wasatch beds of Wyoming, three-eighths nat. size. From the small size of the canine probably a female. Original.

towards the apex, and the posterior face is narrow and concave, forming a groove. The inferior canines are also triangular in section, and the anterior angle is produced into an ala at the base (Figs. 9 *c*, 23 *i*). The neck and tail are of median length.

The general appearance of the Coryphodons, as determined by

the skeleton, probably resembled the bears more than any living animals, with the important exception that in their feet they were much like the elephants. To the general proportions of the bears must be added a tail of medium length. Whether they were covered with hair or not is, of course, uncertain; of their nearest living allies, the elephants, some were hairy and others naked. The top of the head was doubtless naked posteriorly, and in old animals may have been only covered by a thin epidermis, as in the crocodiles, thus presenting a rough, impenetrable front to antagonists.

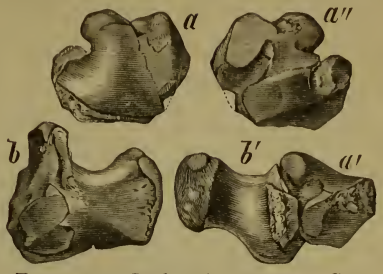


FIG. 19.— *Bathmodon pachypus* Cope, bones of foot of individual represented in figs. 14 and 15, one-fifth nat. size. Fig. *a*, astragalus from above; *a'*, inner side; *a''*, below. Figs. *b b'*, calcaneum.

FIG. 20.—*Coryphodon elephantopus* Cope, skull figured in figs. 12, 17 and 21, two-ninths nat. size, from above. From Wasatch bed of New Mexico. Original, from Report U. S. G. G. Surveys and G. M. Wheeler, Vol. IV, pt. II.

The movements of the Coryphodons doubtless resembled those of the elephant in its shuffling and ambling gait, and may have been even more awkward from the inflexibility of the ankle. But in compensation for the probable lack of speed these animals were most formidably armed with tusks. These weapons, particularly those of the upper jaw, are more robust than those of the Carnivora, and generally more elongate, and attrition preserved rather than diminished their acuteness. The size of the species varied from that of a tapir to that of an ox.

We must suppose that the Coryphodons were vegetable feed-

FIG. 21.—*Coryphodon elephantopus* Cope, skull from left side, two ninths nat. size. From Wasatch bed of New Mexico. Original, from Report U. S. G. G. Survey W. of 100th mer., Vol. IV, pt. II.

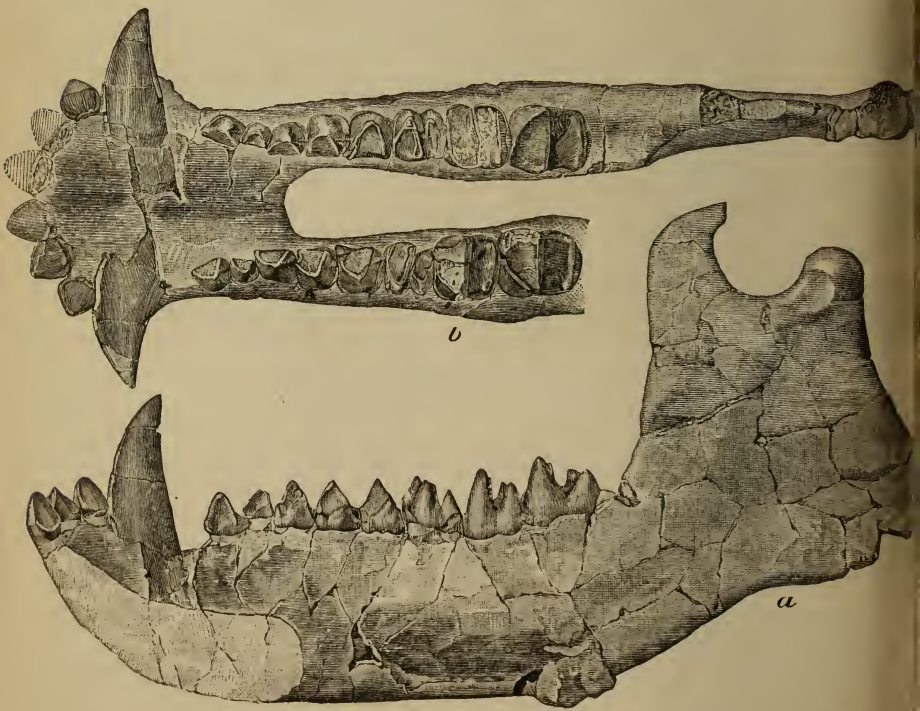


FIG. 22.—*Coryphodon latidens* Cope, lower jaw, one-third natural size, from the Wasatch epoch of New Mexico. Fig. *a*, right ramus from internal side. Fig. *b*, both rami from above. Original, from Report U. S. G. G. Surveys W. of 100th Mer., G. M. Wheeler in charge. This specimen has an anomalous premolar.

ers, but not restricted to any particular class of food. They were doubtless, to a large extent, like the hogs, omnivorous.

Fourteen species of this genus have been described. They range in size from the dimensions of a tapir to those of an ox. In the absence of the bones of the skeleton the species may be distinguished by the inferior true molars, which are fortunately the parts most frequently preserved. The simplest form is that where the posterior crest of the posterior true molar is transverse, and there is no crest or cusp accessory to it on the inner edge of the crown, as in *C. latidens* (Fig. 22). A change in the form of this crest is seen in the *C. curvicristis*, where it is curved forwards at the inner extremity so as to enclose a crescent-shaped valley. This species adds several other peculiarities of this tooth, as the presence of two oblique crests in front of the anterior cross-crest (Fig. 22). The superior incisors are angulate on the external face. The species was of about the same size as the *C. latidens*.

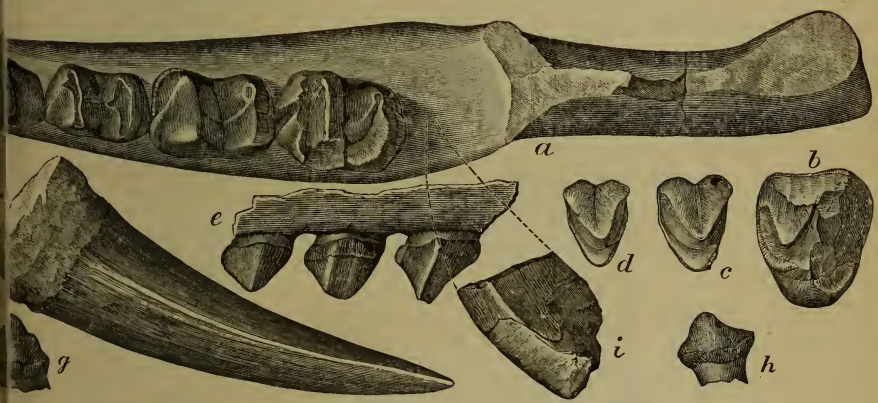


FIG. 22.—*Coryphodon curvicristis* Cope, portions of jaws with teeth, one half natural size, from the Wasatch bed of Wyoming. From Report U. S. Geolog. Survey Terrs., Vol. III. Original. Fig. *a*, right mandibular ramus with true molars and Pm. IV, from above. Fig. *b*, penultimate superior molar from below; *c d*, superior premolars from below; *e*, superior incisors, external side; *f*, superior canine, crown only; *g h*, inferior incisors, external views; *i*, inferior canine, base of crown.

The posterior cross-crest may send off the internal marginal crest at an angle, as in *C. eocænus* Ow., or *C. obliquus* Cope. The internal marginal crest may rise into a low tubercle, as in *C. lobatus* or *C. anax* (Fig. 23 and 9 *b d*). In this case the posterior cross-crest may be very oblique, as in *C. anax*, thus giving the appearance of a heel or fifth lobe to the crown. This is indeed the character of such a crown, which if compared with that of the *C. latidens* only might suggest generic separation, but we

have every intermediate condition. Finally this internal ridge may develop into a conic cusp, as in the *C. cuspidatus* (Fig. 9 *e*).

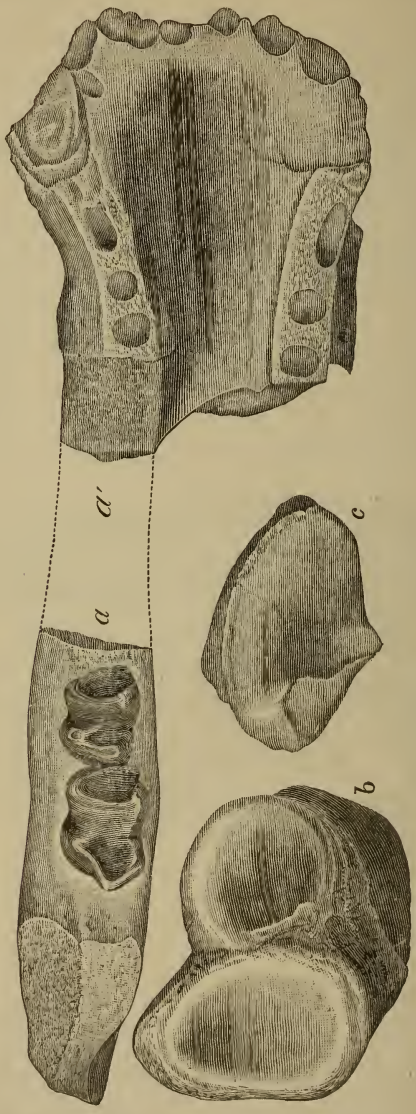


FIG. 23.—*Coryphodon anax* Cope, bones, two-fifths nat. size; individual represented in Fig. 9 *b*. From the Wasatch bed of Wyoming. Figs. *a a'*, mandible, less right ramus, viewed from above. Fig. *b*, head of tibia; *c*, distal extremity of tibia, end views. Original, from Report U. S. Geol. Survey Terrs., Vol. III, F. V. Hayden.

Of Metalophodon two species are known, the *M. testis* (Fig. 16 *b*) and *M. armatus* Cope, both from the Wasatch beds of Wyoming. Both species are of about the size of the *Coryphodon latidens*, and smaller than the *C. anax*. The skeletons are unknown.

(To be continued.)

10a

(*From the American Naturalist, January, 1885.*)

THE AMBLYPODA.

BY E. D. COPE.

(Continued from page 1202, Vol. xviii.)

Dinocerata.

IN this suborder we have a series of mammals which are in some respects the most remarkable that have ever existed. This is true whether we regard the bizarre appearance of their skulls, their dentition, so weak when compared with the bulk of their bodies, or the insignificant size of their brain. We only know them as yet from the Bridger or Upper Eocene formation of North America, with a species possibly from the Wasatch or Lower Eocene.

The characters of this suborder have been already pointed out (Vol. xviii, p. 1121). The differences from the Pantodonta are well marked, but the resemblances are such as to render it impossible to refer the Dinocerata to a different order. Their strong resemblances to the Proboscidia are generally admitted, but the few characters which distinguish them are of the first importance. These are, first, the very small size of the brain, especially of the cerebral hemispheres; and second, the double distal articulation of the astragalus, where the facet for the cuboid bone is nearly as large as that for the navicular.

Within the above definition there is room for much variation, which, however, the known genera do not display. They agree in various points of minor importance. Thus there is no sagittal

crest of the skull, the temporal ridges being lateral, and there is a great transverse supraoccipital crest. These crests are more or less furnished with osseous processes or horns. The middle pair of these (Fig. 29) consists in part of the maxillary bone, and stands in front of or over the eye. The nostrils are well roofed

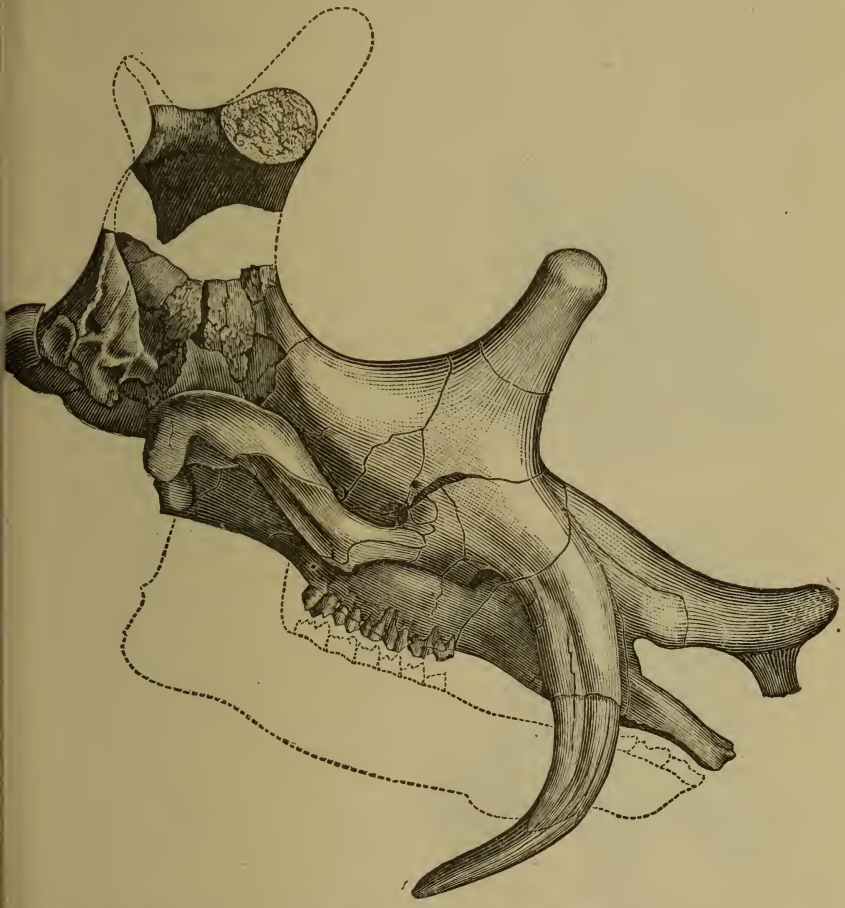


FIG. 24.—*Loxolophodon cornutus* Cope, skull from right side, one-eighth natural size. From the Bridger bed of Wyoming. Original, from Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III. Lower jaw restored from Osborn, Memoir on Loxolophodon and Uintatherium. From individual represented in Pl. I.

over by the nasal bones. There is always a diastema behind the canine tooth in both jaws. There is less difference between the premolar and molar teeth in the known genera than in the Pantodonta, and they all have the same pattern, although the origin of the pattern may be different in the two series. Thus in the upper

jaw the crowns of the molars support two oblique cross-crests, which unite to form a V with the apex inwards. There is sometimes an internal cusp or tubercle. The inferior molars consist essentially of an outer V and a heel; the true molars differ in having the heel a little larger and more recurved on its posterior border, but it does not rise into a transverse crest as in the Coryphodontidæ. Mr. Osborn shows that the inferior incisors in Loxolophodon are compressed and two-lobed.

The known genera agree with the typical Proboscidia in the shape of the scapula with posterior expansion and apical acumination; in the flat carpal bones; in the absence of pit for round ligament of the femur; in the flattened great trochanter, contracted condyles, and fissure-like intercondylar fossa of the same bone. Also in the short calcaneum or heel bone, which is wider than long, and rough on the inferior face; in the five digits on both feet, and the wide peduncle and iliac plates of the pelvis and lack of angular production of the latter beyond the sacrum.

FIG. 25.—*Uintatherium mirabile* Marsh, bones of feet, two-ninths natural size. Upper figure anterior, lower figure posterior feet. From Bridger beds of Wyoming. Slightly altered (lunar bone) from Marsh, *Am. Journ. Sci. Arts*, XI, Pl. VI.

In spite of these resemblances, the Dinocerata are at one side of the line of descent of the mastodons and elephants (see Vol. XVIII, p. 1121, for phylogeny of the hoofed Mammalia). This is indicated not only by the structure of their feet, but by that of their teeth, which, as I have shown, constitute a survival of the tritubercular type which had been left behind by all other contemporary ungulates, and only survived in the flesh-eaters of the Bridger epoch.

The resemblance of the feet to those of Coryphodon may be readily seen by comparing Fig. 25 with Figs. 1–2 (p. 1110, Vol. XVIII). The characters of the component parts are quite identical.

Professor Marsh has given us a figure of the cast of the brain chamber of the *Uintatherium mirabile* Marsh. It displays most striking peculiarities. These are: (1) The small size of the hemispheres; (2) the difficulty of distinguishing the cerebellum from the surrounding parts; (3) the large size of the olfactory lobes (Fig. 26). In all these respects there is a great resemblance to the brain of Coryphodon (Fig. 13). The hemispheres pass into the olfactory lobes by a gradual contraction of their outlines. They rise higher than, and then descend posteriorly towards the mesencephalon and cerebellum. The latter parts, as in Coryphodon, are not distinguished in the cast. The hemispheres are not convoluted, nor is there any sylvian fissure, according to Marsh's figures. This brain, as remarked by Marsh, is the most reptilian among the Mammalia. One of the strongest confirmations of this statement, is the small size of the cerebellum.

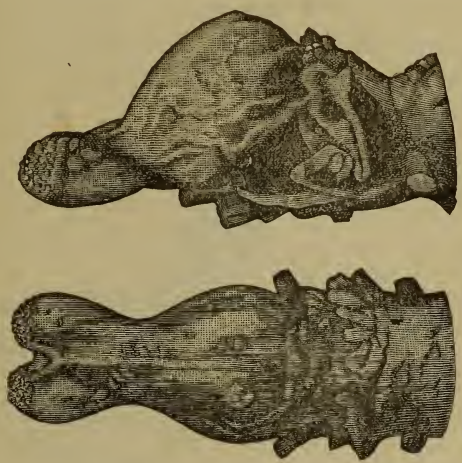


FIG. 62.—*Uintatherium mirabile* Marsh, brain, one-third nat. size. From Marsh, *Amer. Jour. Sci. Arts*, Vol. XI, Pl. IV.

Owing to the imperfect character of the material which I have had the opportunity of examining, it is not possible to state the number of genera with absolute certainty. There are certainly three of these, and probably four. So far as present knowledge goes, they pertain to one family, which I have called the Eobasiliidæ. The three genera mentioned differ in the forms of the mandible; the fourth has certain cervical vertebræ of a peculiar form, but the form of the mandible is unknown. I can only contrast the genera as follows:

A. Mandible unknown.

Certain cervical vertebræ short and flat, as in Proboscidia ..... *Eobasileus.*

AA. Symphysis of mandible with four teeth on each side.

a. Mandible without inferior expansion.

Cervical vertebræ not very short; three premolars; lower incisors bilobate, *Loxolophodon.*

aa. Mandible with anterior inferior expansion.

Cervical vertebræ not short; three premolars..... *Octotomus.*

aaa. Mandible expanded below, its entire length.

Cervical vertebræ unknown; four lower premolars; incisors simple .. *Bathyopsis.*

AAA. Symphysis of mandible with three or two teeth on each side.

Mandible with very narrow symphysis..... *Uintatherium.*

In probably a majority of the species the lower jaw has a deep flange on its inferior border below the canine teeth, which serves, like the corresponding structure in the saber-tooth tigers, to pro-

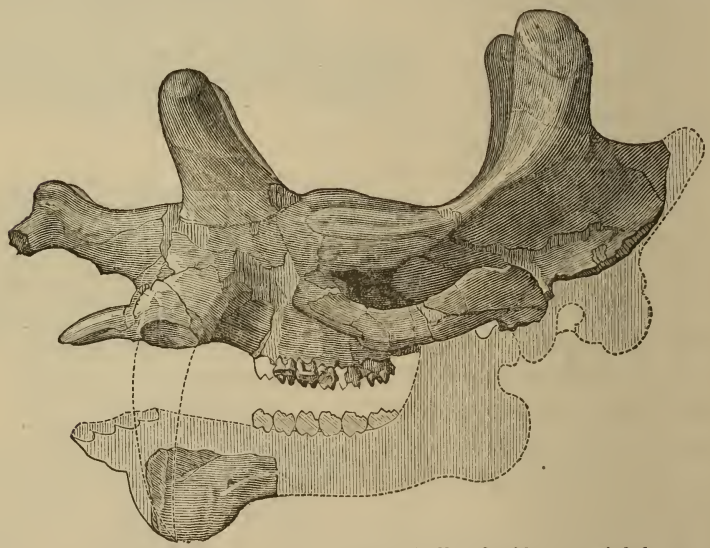


FIG. 27.—*Uintatherium leidianum* Osborn, skull left side, one-eighth nat. size; from the Bridger beds of Wyoming. From Osborn, Memoir on Loxolophodon and Uintatherium.

tect the long superior canine tooth from lateral blows and strains (Fig. 27). In Bathyopsis this inferior expansion includes almost the entire inferior border of the ramus, giving an outline something like that of Megatherium (Fig. 35).

The genus Eobasileus was established on a species (*E. pressicornis* Cope) which is represented by a considerable part of the

skeleton, but without cranium or teeth; hence most of its characters remain unknown. The very short cervical vertebra which belongs to it serves to distinguish it from other genera. A second specimens (*E. furcatus*) found near the first, may belong to it; it includes a fragmentary cranium, but unfortunately no cervical vertebræ. Its introduction into this genus is therefore purely arbitrary.

The typical species is of large proportions, only second in size to the *Loxolophodon cornutus*. Its limbs were more slender in their proportions. It is in this species that I find much evidence in favor of the presence of a proboscis of greater or less length. Should several of the other cervical vertebræ have been as short as the one preserved, it is evident that the animal could not possibly have reached the ground with a muzzle so elevated as the long legs clearly indicate. In the species of the other genera, where the cervical vertebræ are longer, this may have not been the case.

The bones of this species were discovered by the writer in an amphitheater of the bad lands of the Washakie basin, known as the Mammoth buttes, in Southwestern Wyoming. They were in greater or less part exposed, lying on a table-like mass of soft Eocene sandstone. A description of this remarkable locality is given in the *Penn Monthly Magazine* for August, 1872.

The *Eobasileus furcatus* is principally represented by a skull in which the most important features have been preserved. As in all the species of Uintatherium in which the horns are known, these appendages stood in front of the orbits, it is probable that such was the case in the *Eobasileus furcatus* also. The muzzle is materially shorter and more contracted, and the true apex of the muzzle was not overhung by the great cornices seen in *Loxolophodon cornutus*. The occipital and parietal crests are much more extended in this species than in the *L. cornutus*, so that in life the snout and muzzle had not such a preponderance of proportion as in that species. All the species of this genus were rather rhinocerotic in the proportions of the head, although the horns and tusks produced a different physiognomy.

The known species of Loxolophodon Cope, are the largest of the order. Three species are known to be distinct: the *L. cornutus* Cope, *L. galeatus* Cope, and *L. spierianus* Osborn. They differ in the form of the horns and in the shape of the occiput.

The cranium in this genus is elongated and compressed. The muzzle is posteriorly roof-shape, but is anteriorly concave and flattened out into a bilobed protuberance which rises above the extremity of the nasal bone. This extremity is subconic and short and decurved. A second pair of horn-cores stands above the orbits, each one composed externally of the maxillary bone, and internally of an upward extension of the posterior part of the nasal. Behind this horn the superior margin of the temporal fossa sinks, but rises again at its posterior portion, ascending above the level of the middle of the parietal bones. The occipital rises in a wall upwards from the foramen magnum and supports, a little in front of the junction with the superior and posterior crests bounding the temporal fossa, a third horn-core on each side.

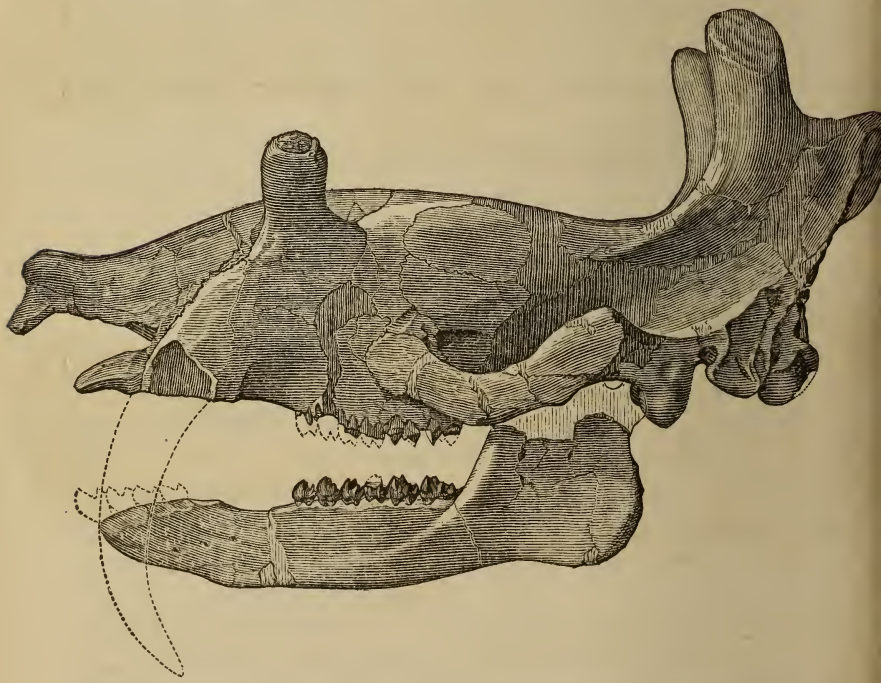


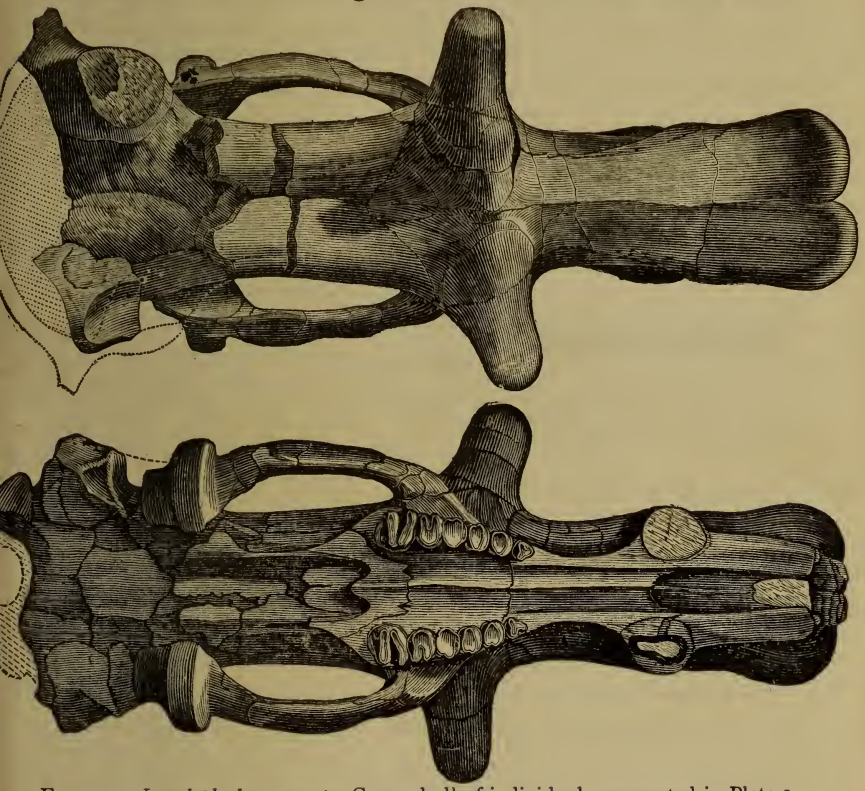
FIG. 28.—*Loxolophodon spierianus* Osborn, skull rom left side, one-eighth natral size; from the Bridger beds of Wyoming. From Osborn, Memoir on Loxolophodon, etc.

The three species may be distinguished as follows:

Median horns triangular in section, with internal tuberosity, and above orbits; occiput narrow.....*L. cornutus.*
Median horns subquadrate in section without internal tuberosity; occiput and nasal tubercles wide.....*L. galeatus.*
Median horns subround and without tuberosity, in front of orbits; occiput and nasal tubercles narrow.....*L. spierianus.*

The *Loxolophodon spierianus* Osborn, was as large an animal as the two others, and had a very elongate skull with weak horns and narrow, high occiput. Its median horns are situated well anterior to the orbit, and its zygomatic fossa is remarkably small. It was discovered by the Princeton scientific exploring party at the same locality that produced the other species, viz., the Mammoth buttes of Southwestern Wyoming (Fig. 28).

In the *L. cornutus* and *L. galeatus* the tuberosities which stand



FIG, 29.—*Loxolophodon cornutus* Cope, skull of individual represented in Plate I, one-eighth nat. size. Upper figure superior surface; lower figure inferior surface. From Bridger Eocene of Wyoming. Original, from Report U. S. Geol. Survey of Terrs., F. V. Hayden in charge, Vol. III. Owing to distortion of the specimen behind, the occipital condyles are too far apart in the figure.

near the free extremity of the nasal bones are greatly developed, so as to represent a pair of cornices projecting upwards and forwards over the narrow apex of the bones (Fig. 24). From above, the end of the muzzle in those spcices has a bilobate outline. They differ from each other materially in form of the middle pair of horns.

Mr. Osborn, of Princeton, has published a description of the lower jaw and teeth of a species of Loxolophodon, which he identifies with the *L. cornutus*, which was derived from the locality and horizon of the species above mentioned (Fig. 8). They show that the descending flange of Uintatherium and Bathyopsis is only represented by a convex ridge on each side of the symphysis. They point out the characters of the dentition, which are remarkable. The molars much resemble those of Bathyopsis. The canines and incisors are alike in form, and in a continuous series. The crowns are compressed so as to be extended anteroposteriorly, and are deeply emarginate, so as to be bilobed, the lobes with subacute edges. This form of incisors is unique, resembling only remotely the large median incisors of certain Insectivora (Fig. 30). Resemblance to mammals of the same type may be traced in the molar teeth.

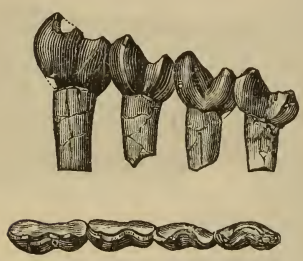
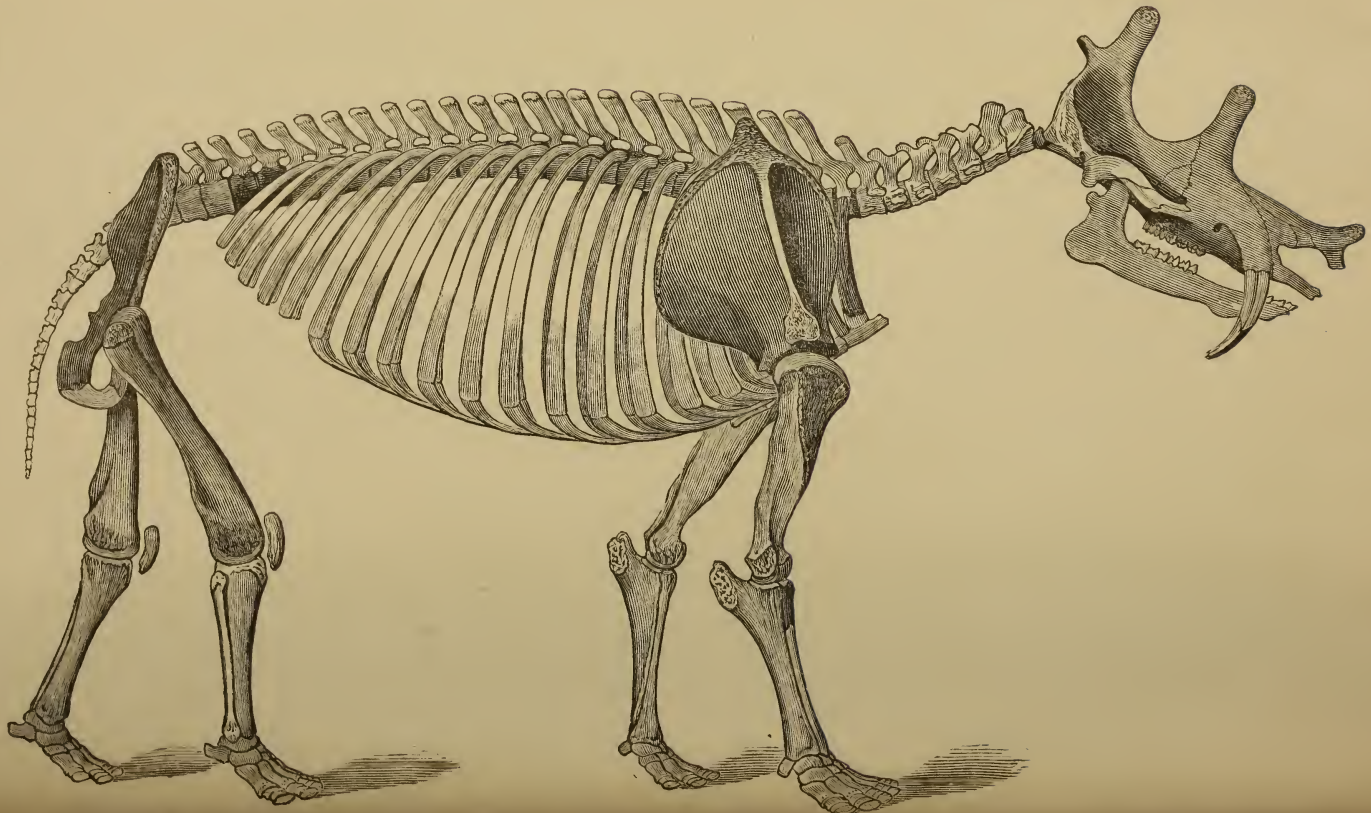


FIG. 30.—Incisor and canine teeth of left side of lower jaw of Loxolophodon, one-fourth natural size. From Osborn.

We may ascribe to the *Loxolophodon cornutus* form and proportions of body similar to those of the elephant (see Plate 1). The limbs, however, were somewhat shorter, as the femur (Fig. 31) is stouter for its length than in the *E. indicus*. It was intermediate in this respect between the latter species and the species of Rhinoceros. The tibia is relatively still shorter. The tail was quite small. The neck was a little longer than in the elephants, but much less than in the rhinoceroses; the occipital crest gave attachments to the *ligamentum nuchæ* and muscles of the neck, which must needs have been powerful to support the long muzzle with its osseous prominences, and to handle with effect the terrible laniary tusks. The head must have been supported somewhat obliquely downward, presenting the horns somewhat forward as well as upward. The third or posterior pair of horns towered above the middle ones, extending vertically with a divergence when the head was at rest. The posterior and middle pair of horns were no doubt covered by integument in some shape, but whether dermal or corneous is uncertain. Their penetrating foramina are smaller than in the Bovidæ. The cores have remotely the form of those of the *Antilocapra americana*, whence I suspect that the horns had an inner process or angle as in the



Loxolophodon cornutus Cope restored to $\frac{1}{27}$ nat. size. The darkly shaded portions are those in my possession; the feet and caudal and cer-

prong-horn at present inhabiting the same region. The nasal shovels may have supported a pair of flat divergent dermal tuberosities, but this is uncertain; they are not very rugose.

The elevation of the animal at the rump was about six feet, distributed as follows, allowance being made for the obliquity of the foot:

	Inches.
Foot	4.50
Tibia	20.50
Femur	31.75
Pelvis	16.00
	72.75

The anterior limbs were stouter than the posterior, judging

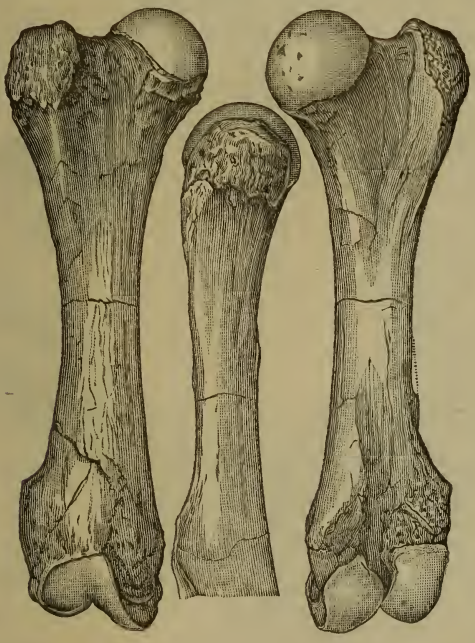


FIG. 31.—*Loxolophodon cornutus* Cope, femur of individual represented in Pl. I, one-ninth nat. size. From Bridger beds of Wyoming. Original, from Report U. S. Geol. Surv. Terrs., III, F. V. Hayden in charge.

from the proportions in various species, and were no doubt longer if of the Proboscidian character. This would give us the hypothetical elevation at the withers:

	Inches.
Leg	61.00
Scapula (actual)	21.00
Neural spines (extremities)	7.00
Or 7 feet 5 inches	89.00

These measurements are made from the plantar and palmar surfaces, allowance being made for the pads.

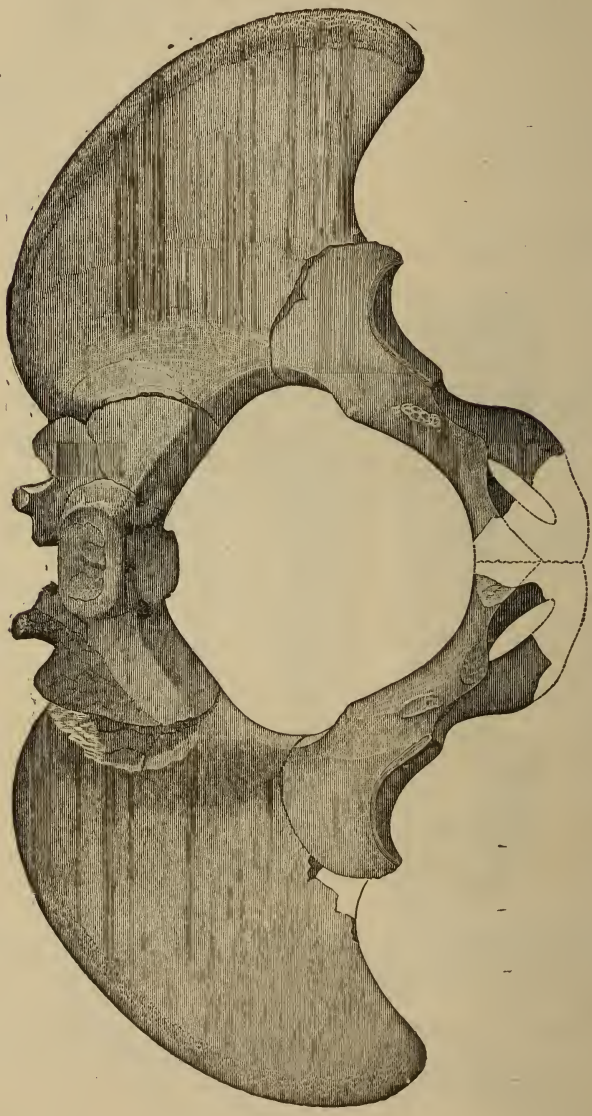


FIG. 32.—*Loxolophodon cornutus* Cope, pelvis of individual represented in Pl. 1; from front; one-eighth nat. size. Original.

The obliquity of the anteroposterior axis of the anterior dorsal vertebra indicates that the head was posteriorly elevated above the axis of the dorsal vertebræ. Owing to the lack of cervical ver-

tebræ, the length of the neck cannot be determined. It may have been short, as in the *Eobasileus pressicornis*, or longer, as in the species of Uintatherium. The indications derived from the bones of the muzzle point to the attachment of a heavy upper lip. The numerous rugosities of the posttympanic and mastoid regions indicate the insertions of strong muscles. Some of these may have been adductors of large external ears.

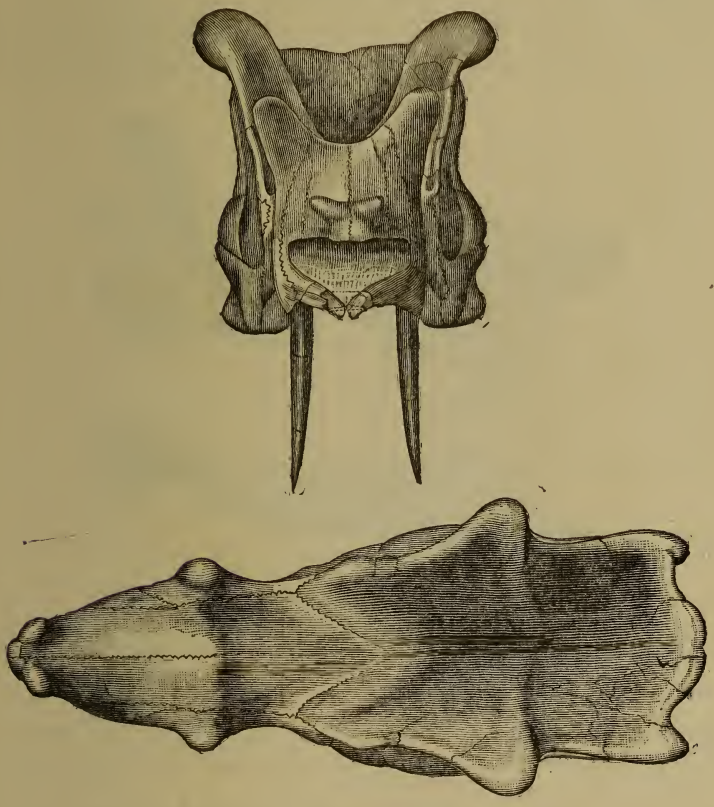


FIG. 33.—*Uintatherium mirabile* Marsh, skull, one-eighth nat. size; upper figure from front, lower figure from above. From Bridger Eocene of Wyoming. From Marsh, *Amer. Jour. Sci. Arts*, XI, Pl. II.

The inferior incisor teeth have no adaptation for cutting off vegetation. The mental foramen is small, but the small nutrient artery thus indicated is not adverse to belief in a prehensile under lip to make up for the uselessness of the teeth. The projecting nasal regions would prevent short lips from touching the ground.

The posterior position of the molar teeth indicates use for a long, slender tongue.

The species was probably quite as large as the Indian elephant, for the individual described is not adult, as indicated by the freedom of the epiphyses of the lumbar vertebræ; and fragments of others in my possession indicate considerably larger size.

The very weak dentition indicates soft food, no doubt of a vegetable character, of what particular kind it is not easy to divine. The long canines were no doubt for defence chiefly, and may have been useful in pulling and cutting vines and branches

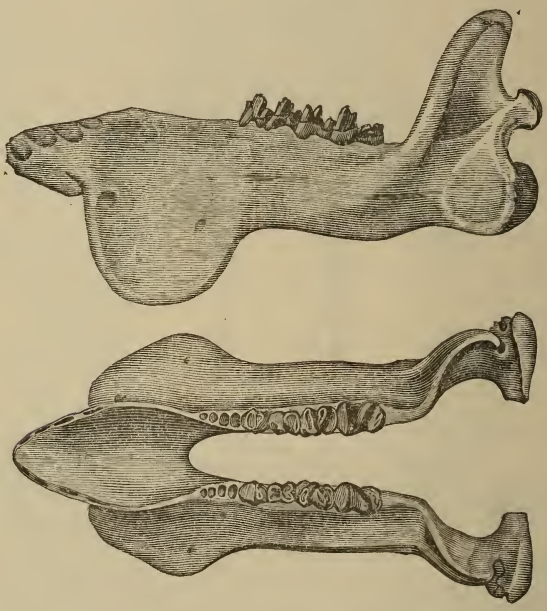


FIG. 34.—*Octotomus laticeps* Marsh, lower jaw, one-eighth nat. size; upper figure left side, lower figure from above. From Marsh, *Amer. Jour. Sci. Arts*, XI, Pl. V.

of the forest. The horns furnished formidable weapons of defence. The anterior nasal pair might have been used for rooting in the earth, if the elevation of the head did not render this impossible.

This huge animal must have been of defective vision, for the orbits have no distinctive outline, and the eyes were so overhung by the horns and cranial walls as to have been able to see but little upward. The muzzle and cranial crests have obstructed the

view both forward and backward, so that this beast probably resembled the rhinoceros in the ease with which it might have been avoided when in pursuit.

The genus Uintatherium Leidy, has the symphysis of the mandible more contracted than in the other genera, and the number of its teeth correspondingly reduced.[1] The type is the *U. robustum* Leidy, a species which is known from the posterior part of a skull with a few molar teeth of both jaws, and a superior canine tooth of one individual; and by the greater part of the lower jaw of another. It is of smaller size than those referred to Loxolophodon, and also smaller than the *U. leidianum* Osb. (Fig. 27). Besides these two species four others have been described by Marsh and referred to a genus Dinoceras, which is not yet known to be distinct from Uintatherium. The best known of these is the *U. mirabile* (Figs. 25, 26, 33), which has been well figured by Marsh. It lacks a tubercle of the last superior molar which is present in the *U. robustum*. Its lower jaw is unfortunately unknown. A species described by Marsh as *Dinoceras laticeps* is of larger size than the *D. robustum*, and Marsh figures its lower jaw (Fig. 34). It possesses four teeth on each side of the symphysis, as in Loxolophodon, but their form is not known. There is a deep flange of the lower edge of the ramus below the canine teeth, as in Uintatherium. As this form represents a genus clearly distinct from either of these, or Bathyopsis, I propose that it be called Octotomus. To this genus may belong some of the species now provisionally referred to Uintatherium.

In these animals the nasal tuberosities are small, and do not overhang the apex of the nasal bones. The median horns are anterior to the orbits, and are of various degrees of development in the different species. The posterior horns vary in like manner (compare Figs. 27 and 33). The supraoccipital crest extends much further posteriorly in the *U. mirabile* than in some of the other species.

In the genus Bathyopsis Cope, not only the incisors and canines, but also the molars are of the full number, *i. e.*, I. $\frac{3}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{4}$; M. $\frac{3}{3}$. This, with the posteriorly extended expansion of the ramus of the lower jaw, distinguishes it from the other genera. But one species is known, the *B. fissidens* Cope, which

[1] See Cope, Proceeds. Academy Philadelphia, 1883, p. 295.

was an animal probably as large as the Javan rhinoceros (*Rhinocerus sondaïcus*), or rather smaller than the *Uintatherium robustum*.

The characters of the inferior molars in this and other genera of Dinocerata are very peculiar. In Bathyopsis they are constructed on the plan of those of insectivorous marsupial and placental mammals, so as to lead to the suspicion that its food consisted of Crustacea, or insects of large size, or possibly of thin-shelled Mollusca.

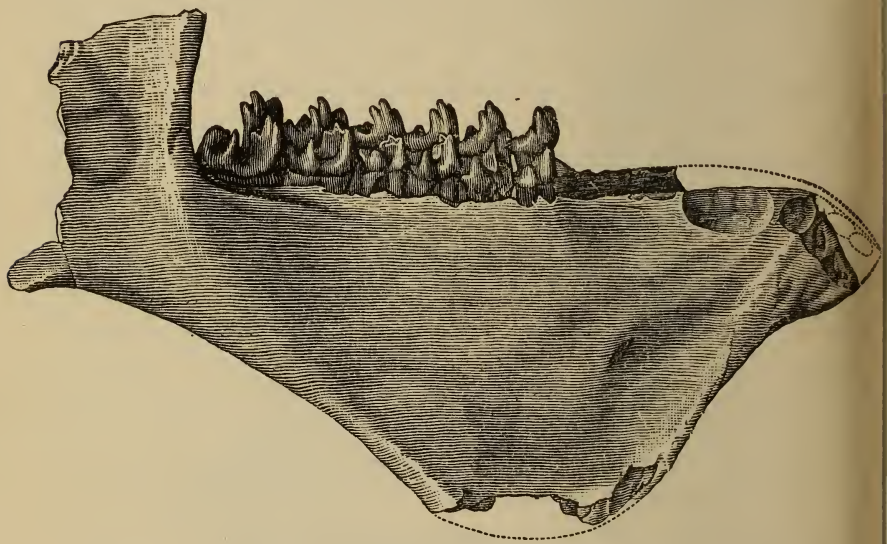


FIG. 35.—*Bathyopsis fissidens* Cope, mandible from right side, four-ninths nat. size. Specimen represented in Fig. 7. From the Wind River (Bridger) bed of Wyoming. Original, from Vol. III, U. S. Geol. Survey Terrs., F. V. Hayden.

The form of the ridges of the anterior part of the jaw of the *Bathyopsis fissidens*, together with the remarkably large dental canal and mental foramen strongly suggest that the animal possessed a large and perhaps prehensile lower lip. The lateral descending crests of the lower jaw must have affected the physiognomy curiously, especially when viewed from the front.

In the history of the discovery of the various types of the Amblypoda, we have an illustration of the prevision which the palæontologist may exercise as a legitimate inference from known facts. In closing his memoir on these animals (p. 44) Mr. Osborn remarks: "In the Upper Cretaceous or early Eocene lived a

group of animals which were the common ancestors of the Dinocerata and Pantodonta." This was written and published in 1881. In the following year, 1882, I discovered the Pantolambdidæ in the lowest Eocene bed known in America. How well this family fulfills the anticipations of Mr. Osborn may be seen by reference to the earlier pages of this essay on the Amblypoda (see NATURALIST, Vol. XVIII, p. 1111).

The tracing of the phylogeny of the Amblypoda from its earliest to its latest representatives, has presented us with an interesting chapter in brain evolution. It has been asserted[1] by Lartet, and repeated by Marsh, that there has been a continuous progress in the increase in the size and complexity of the brain in the Vertebrata, with the passage of geological time. This principle, as a whole, is confirmed by the results of my own studies. The Amblypoda constitute the sole exception known to me. The brain of the *Pantolambda bathmodon*, though of the same type as other Amblypoda, is relatively much larger than in its descendants of the Dinocerata and Pantodonta. It is a clear case of retrogression, and not of progression, in brain development.

[1] *Comptes Rendus*, June, 1868.

11

THE CREOD

(*From the American Naturalist, March, 1884.*)

THE CREODONTA.

BY E. D. COPE.

PRESENT knowledge justifies the generalization that, since the Eocene period, the mammalian fauna of the Northern hemisphere has diminished in the number of its species and genera. The Eocene fauna was richer than the Miocene; the Miocene than the Pliocene, and the Pliocene was richer than the modern fauna. With this numerical diminution in species has come increased specialization of structure, which means both greater perfection of mechanism and greater diversity of type.[1]

The order of Carnivora is a universal and well-known factor of the mammalian life of the present period. It was equally so in the Pliocene and Miocene periods. When we come to examine the overflowing life of undoubted Eocene time, we can no longer find mammals which possess the essential characters of the order. The Carnivora are unguiculate gyrencephalous mammalia with a coössified scaphoid and lunar bone of the carpus, called, therefore, the scapholunar bone. They have a grooved astragalus. No scapholunar bone has yet been found in any Eocene mammal in North America, and it is doubtful whether any has been found in Europe. Nevertheless the Eocene fauna did not lack predatory flesh-eaters whose function was like that of the Carnivora of later periods, to restrain the undue increase of all other forms of life. Their variety was greater than that presented by their carnivorous successors on the North American continent, and their numbers were proportioned to the general luxuriance of the life which furnished them subsistence. There were species whose size and powers of destruction equaled those of the bears, lions and tigers of modern times. Species of medium size abounded,

[1] This generalization was published in the Report U. S. G. G. Survey W. of 100th meridian, 1877, IV, p. 385.

while the smaller forms, representing in function the civets and weasels of to-day, were especially numerous.

The systematic position of these animals has been difficult to determine with satisfactory precision, owing to the imperfect knowledge which we possess of their structure. Besides lack of scapholunar bone, they nearly all differ from the Carnivora in their ungrooved astragalus, and their greatly reduced and smooth cerebral hemispheres. Their position then can only be with the Marsupialia or the Insectivora. The superficial resemblances are often to the former order, where the carnivorous types Thylacinus, Sarcophilus, Dasyurus and the opossums, seem to present near affinities, if the structure of the teeth only is to be considered. Laurillard, DeBlainville and Gaudry have, at different times, assigned to them this position. It is true, however, that no one osseous character, except the possession of marsupial bones, has yet been discovered which characterizes the order Marsupialia. It rests chiefly on the characters of its soft parts, especially of the brain and reproductive system. Most marsupials have the angle of the lower jaw inflected; the Eocene flesh-eaters do not. The carnivorous marsupials generally have more than six incisor teeth; the Eocene flesh-eaters have six or less. The marsupials generally have perforated palates; the Eocene forms never display the character. No marsupial bones have yet been found in the Eocene forms (with the possible exception of Mioclænus), so that we cannot yet find the necessary reasons for placing our extinct forms with the order which possesses them. On the other hand the brain was probably marsupial in its internal character, as it certainly was in its external character. Finally, the discovery of the character of the temporary dentition in the Eocene flesh-eaters has added force to the view that they cannot be marsupials. M. Filhol has shown that in Hyænodon there were three temporary molars, and I have proven that there were at least two in Triïsodon. There is, according to Flower, but one in the Marsupialia. It is, however, to be remembered that true marsupials, opossums, occur in the Oligocene in both North America and Europe (genus Peratherium Aym.), and that they resemble their Eocene predecessors very much, especially in the constitution and form of the molar teeth.

The comparison with the Insectivora betrays no such fundamental diversities as that with the Marsupialia. The differences

are of minor import, although in particular cases considerable. In spite of their often large size and evidently predatory habits, the Eocene flesh-eaters must be placed with the Insectivora. But as I have already pointed out,[1] they have contemporaries which must go with them. These are two groups, the one with rodent, the other with edentate tendencies, the Tillodonta and Tæniodonta. The former of these is intimately allied to the living Chiromys of Madagascar, which itself is almost a lemur, by gen-

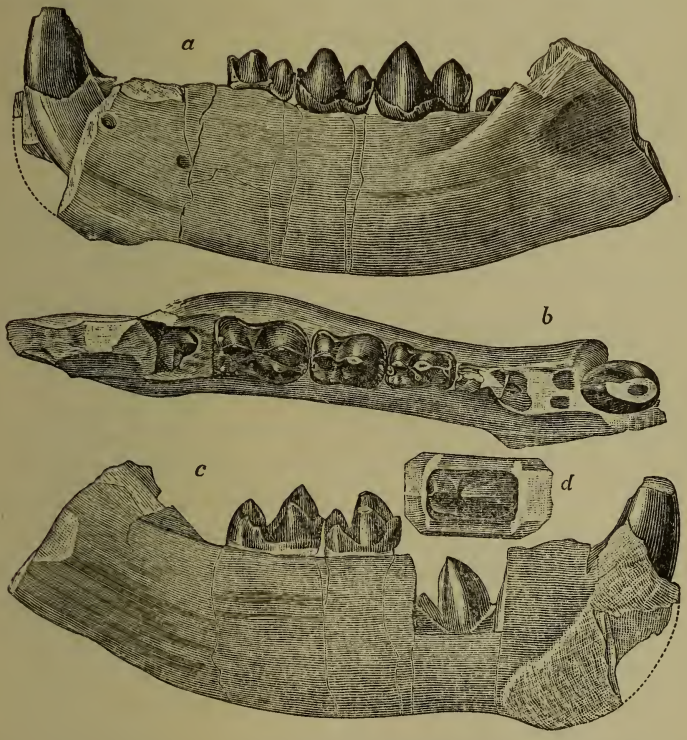


FIG. 1.—Left mandibular ramus of *Tritisodon quivirensis* Cope, three-fourths nat. size, from the Puerco beds of New Mexico. Fig. *a*, external view, displaying the last temporary molar in place; *b*, the same from above; *c*, the same, internal side, the temporary molar removed and the permanent fourth true molar displayed in the jaw; *d*, the fourth permanent premolar viewed from above. Original; from Vol. IV, Report U. S. Geological Survey Terrs., F. V. Hayden in charge.

eral consent. The whole of this assemblage I have regarded as an order of mammals to which I have given the name of the Bunotheria. In this order there are included six suborders, and

[1] Report U. S. G. G. Surveys W. of 100th meridian, G. M. Wheeler in charge, IV, p. 85, 1877. Proceedings Academy Philadelphia, 1883, p. 77.

the carnivorous type of this series, the group now under discussion, I have called the Creodonta.[1] Its definition is as follows:

Neither incisor nor canine teeth growing from persistent pulps. Hallux not opposable. Superior true molars tritubercular or more simple.

The only character which distinguishes the suborder from the Insectivora is the possession of tritubercular or more simple molars above. This is, as I have shown,[2] a feature of more importance than has been hitherto supposed. The tritubercular molar is the primitive type from which the quadritubercular has been directly derived. It has furnished the starting point for both the carnivorous and the herbivorous dentitions, since it was common to both the clawed and hoofed mammals of the Puerco, or lowest known epoch of the Eocene period.

So far as known, the Creodonta were all plantigrade, and had long tails, and were mostly five-toed. With the possible exception of *Protopsalis tigrinus*, they all had relatively larger heads and shorter legs than the majority of the Carnivora of the present period. This is true of all the recent Creodonta, none of which reach the dimensions of many of the fossil forms.

The contents of the suborder Creodonta display, in their modifications, the usual range of simplicity and complexity consistent with the type, and the families may be arranged in some sort of phylogenetic order, in accordance with this principle. Nevertheless a difficulty arises as to what are ancestral or primitive conditions, and what characters, if any, must be regarded as the result of degradation. As other parts of the skeleton are less frequently obtained, these considerations relate chiefly to the dentition.

In my paper on the Homologies and Origin of the types of Molar Teeth, etc.,[3] I pointed out that the cone was the simple form of tooth from which all others must have been derived. In the Mammalia this may have been modified in several ways simultaneously, but two methods present themselves as the most certain secondary primitive types. The first of these is that of the simple premolar, where the cone is compressed, and is sooner or later followed by a horizontal extension or heel. This type persists in

[1] For greater detail on this topic, see Proceedings Philadelphia Academy, 1883, p. 77.

[2] Proceedings American Philosophical Society, 1883, p. 324. Palæontological Bulletin, No. 37.

[3] Journal Academy Nat. Sciences Philada., 1874, March.

the inferior true molars of the Mesonychidæ. The second modification consists in the addition of lateral cusps or spines to the simple cone. Such a type is seen in inferior molars of *Spalacotherium tricuspidens* Ow., of the Jurassic period, and in some of the incisors of *Plesiadapis tricuspidens*[1] Gerv. This form, by the shifting of the two subordinate cusps to the inner side of the principal one, will give a trituberculate molar of the lower series, an exaggeration of which is seen in the South African "mole,"

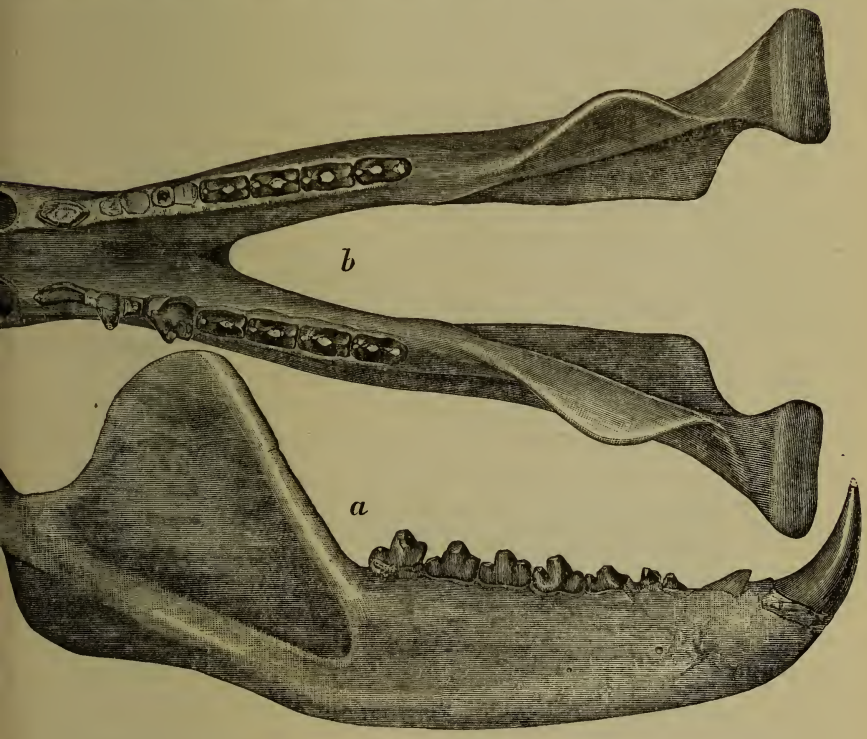


FIG. 2.—Mandible of *Mesonyx ossifragus* Cope, from the Wasatch epoch of the Big Horn river, Wyoming, one-third nat. size. Original. From Report U. S. G. S. Terrs., Vol. III.

Chrysochloris. If a cingulum appears at the posterior base of such a tooth, we have a rudimental "heel," such as is seen in Centetes, and is still better developed in many creodont and marsupial genera, forming the basis of the inferior sectorial tooth of the Carnivora. This, which I have called the "tubercular-secto-

[1] Lemoine. Communication sur les Ossemens Fossiles d. env. Reims, p. 9, pl. II, fig. 13. The superior dentition of this specimen is represented in fig. 6.

rial," is especially well marked in Oxyæna (Fig. 3) and Stypolophus.

All stages of diminution of the anterior of the two inner cusps of the inferior molars may be seen in the genera of Centetidæ, as for instance in Ictops and Diacodon, until a true quadritubercular molar is reached as in Mioclænus. In Miacis and Didymictis one tubercular-sectorial remains with one or more tuberculars. The process of developing a tubercular inferior molar from a tritubercular tooth, is the reverse of what has taken place in the Carnivora, where the tubercular-sectorial has, by loss of parts,

FIG. 3.—*Oxyæna forcipata* Cope, mandible from the Wasatch bed of New Mexico, one-half natural size. Original from Report U. S. G. G. Survey W. of 100th mer. G. M. Wheeler, Vol. IV. The numbers indicate the approximate premolars and true molars.

become a true sectorial. With these explanatory remarks I present the following definition of the families. I have formerly used the shape of the astragalus as a family definition. In the majority of the Creodonta its trochlear face is not grooved. In the Mesonychidæ it is strongly grooved. In Mioclænus and some species of Stypolophus, as well as in the moles, it is slightly grooved:

I. Inferior molars premolariform.

Inferior molars consisting of a cone and heel.....*Mesonychidæ.*

Inferior molars with a blade formed of anterior and median cusps...*Hyænodontidæ*

II. Inferior molars tritubercular without heel.

No sectorial teeth; tibia and fibula coössified.....*Chrysochloridida.*

III. Inferior molars tritubercular-sectorial or quadritubercular.

a. No superior sectorial teeth.

Tibia and fibula distinct; no zygomatic arch.....*Centetidæ.*

Tibia and fibula distinct; zygomatic arch present.....*Leptictidæ.*

Tibia and fibula coössified; external tubercles of superior molars subconic, no clavicles.....*Mythomyidæ.*[1]

Tibia and fibula coössified; external tubercles two Vs; clavicles.....*Talpidæ.*

aa. First true superior molar sectorial.

Tibia and fibula distinct; no tubercular molars.....*Oxyænidæ.*

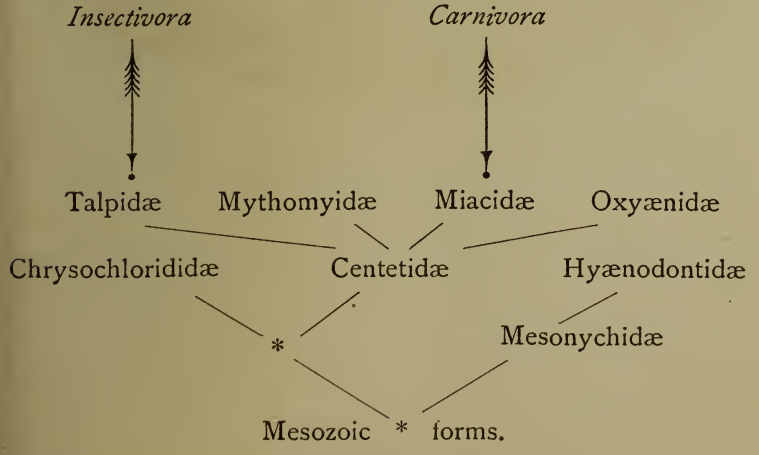
aaa. Fourth superior premolar sectorial.

Tibia and fibula distinct; true molars tubercular.....*Miacidæ.*

The number of genera and species embraced by these families is as follows. The extinct forms only are enumerated, and those of North America are specified:

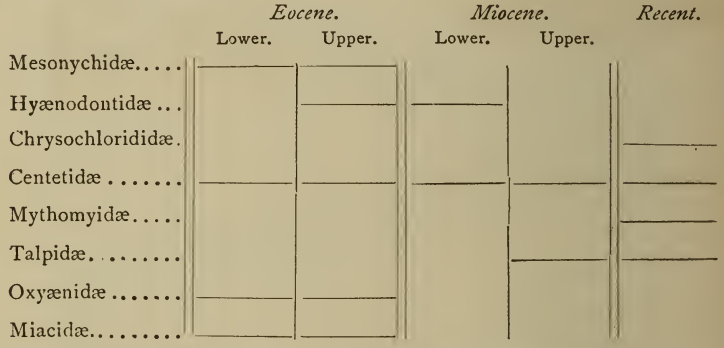
Families.	*Genera.*	*Species.*	*N. America.*
Mesonychidæ	4	7	7
Hyænodontidæ	1	10	3
Chrysochloridida	*	*	
Centetidæ	18	44	37
Mythomyidæ	*	*	
Talpidæ	*	*	
Oxyænidæ	3	7	4
Miacidæ	2	12	12
Totals	28	80	63

The affinities of these families may be expressed in the following diagram, which may be regarded as an attempted phylogeny also:



[1] This family is sometimes called the *Potamogalidæ*. Mythomys is, however, the name first published, with a description, for the typical and only genus.

In geological time the Mesonychidæ, Miacidæ and Oxyænidæ are confined to the Eocene period. The Hyænodontidæ extend through the Upper Eocene and Oligocene or Lowest Miocene formations. The Centetidæ are predominately Eocene, but in North America they are also found in the Oligocene. In recent times they are only known in the islands of Madagascar and Cuba. The Chrysochlorididdæ are modern and African, while the Talpidæ commence in the Middle Miocene in Europe, and are as abundant in recent times in the Northern hemisphere. Mythomyidæ are only known as recent in Africa. These relations may be expressed as follows:



The distribution of the genera with relation to the American formations will be considered later.

Mesonychidæ.

In this family the form of the inferior molars is not very different from that displayed by the last lower premolars of carnivorous Mammalia generally. The superior molars are of correspondingly simple structure, in like manner resembling the last premolars of the superior series of Carnivora and some other Mammalia. There are two types in the family. In the first, the astragalus is flat, as in most Creodonta (Fig. 5 *a b*). The only known genus is Amblyctonus, which I have, on account of its astragalus, placed in a separate family, the Amblyctonidæ. This course may be justified by future discovery. The inferior molars also differ from those of Mesonyx in the development of the anterior cusp, thus approaching the Hyænodontidæ (Fig. 4). The bones of *Amblyctonus sinosus* Cope, are about as robust as those of the coyote. They have so far been found only in the Wasatch beds of New Mexico. M. Fischer has described an allied mam-

mal from France under the name *Apterodon gaudryi*. He has not stated how this genus differs from Amblyctonus.

Fig. 4.

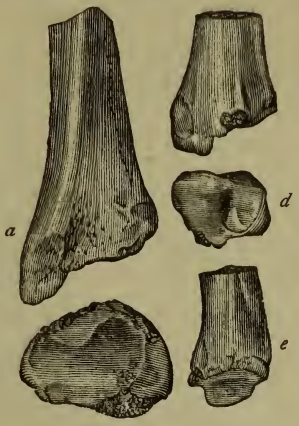


Fig. 5.

FIG. 4.—Part of mandibular ramus of *Amblyctonus sinosus* Cope, with the last three molars; upper figure the same, from above; two-thirds nat. size. From the Wasatch beds of New Mexico. FIG. 5.—Distal ends of tibia of, *a–b*, *Amblyctonus sinosus*, and *c d e*, *Oxyæna morsitans* Cope; *b* and *d*, distal views; two-thirds natural size. From the Wasatch beds of New Mexico. Original, from U. S. G. G. Expl. Surv. W. of 100th mer., G. M. Wheeler.

In the genus Mesonyx we have a structure of the astragalus found only elsewhere in flesh-eating mammals in the Hyænodon.[1] Its distal extremity has two well-marked facets, one for the navicular bone and one for the cuboid (Fig. 9). The appearance is that of a perissodactyle mammal, and the astragalus of the Mesonyx might well be taken for that of an ungulate of that suborder. The tibial face of the bone is grooved, another point in which it differs from most of the Creodonta. Still another characteristic peculiarity is seen in the forms of the ungues. These are neither claws nor hoofs, but between the two, resembling the corresponding part in some Rodentia. Their deeply fissured extremities show that they are rather allied to claws than to hoofs (Fig. 10). The narrow navicular facet of the astragalus renders it probable that the inner digit or hallux is wanting, and that there are but four toes in the hinder foot. The form of the trapezium shows that there are but four toes on the anterior foot (Fig. 7). One more character completes the singular ensemble presented by this genus. The zygapophyses of the lumbar vertebræ embrace each other as in the lower perissodactyles and artiodactyles, a character not found in the Carnivora or Insectivora.

[1] Fide Professor W. B. Scott.

Among the Creodonta I have only observed it elsewhere in the genus Mioclænus,[1] but the vertebræ of many of these animals are unknown. It is wanting in Thylacinus and the opossum, and rudimental in Sarcophilus, among marsupials.

Three species of the genus Mesonyx are known, *M. ossifragus*

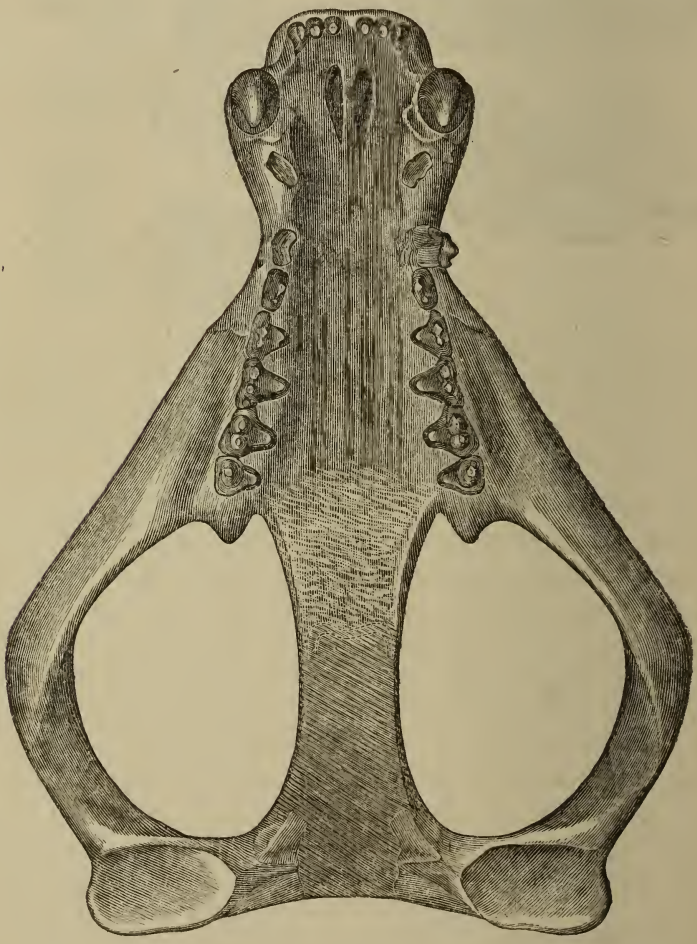


FIG. 6.—*Mesonyx ossifragus* Cope, skull anterior to postglenoid processes, inclusive, from below; one-third natural size. From the Wasatch beds of Wyoming. Original, from Report U. S. Geol. Surv. Terrs., III, F. V. Hayden.

Cope, from the Wasatch Eocene, and *M. lanius* and *M. obtusidens* Cope, from the Bridger. The last named is the type. It is about the size of the wolf, and had more slender feet and claws than

[1] Proceedings American Philos. Society, 1883, p. 543.

the other two. The *M. lanius* was considerably larger than the *M. obtusidens*, equaling the black bear (*Ursus americanus*) in size It had a large head, with a long, rather narrow and truncate. muzzle. The limbs were relatively smaller, not exceeding those of the black bear in length and thickness. The tail was long and slender as in the cats, while the claws were broad and flat as in the beaver.

The molar, canine and incisor teeth of my specimen, as well as those of one in the Princeton Museum, are much worn by use. This is especially true of the canines of both, while the crowns of the molars of my Bitter Creek specimen are almost entirely worn away. The same peculiarity is to be observed in the specimens of the allied *Amblyctonus sinosus*, which I obtained in New Mexico. It is probable that these species chewed hard substances. The peculiar approach of the lower canines is a special modification for peculiar habits, which I suspect to have been the devouring of the turtles which so abounded on land and in the waters of the same period. The slender symphysis could most readily be introduced into the shell, while the lateral pressure of the upper canines with the lower, would be well adapted for breaking the bony covering of those reptiles. The breaking of these shells in the attempt to masticate their contents would produce the unusual wear of the teeth observed.

FIG. 7.—*Mesonyx lanius* left anterior foot, one-half natural size. Upper figure first row of carpal bones of right side of same individual, proximal view. Original. From the Bridger beds of Wyoming.

The *Mesonyx ossifragus* is the largest species, its skull exceeding that of the grizzly bear in dimensions (Figs. 2, 6, 8, 9 and 10). It was originally found by the writer in the Wasatch beds of New Mexico, and was afterwards found by Mr. Wortman to be not uncommon in the corresponding formation in Northern Wyoming. From material obtained by this gentleman, we can form a general idea of the form and proportions of the *Mesonyx ossifragus*. We can depict an animal as large as a large-sized American black bear, with a long, stout tail and a wide head as large as that of a grizzly bear. The fore limbs are so much shorter than the hind limbs

that the animal customarily sat on its haunches when on land. In walking, its high rump and low withers would give it somewhat the figure of a huge rabbit. Its neck was about as long as that of an average dog. Its tread was plantigrade, and its claws like those of various rodents, intermediate between hoofs and claws. The animal, to judge from its otter-like humerus, was a good swimmer, although there is nothing specially adapted for aquatic

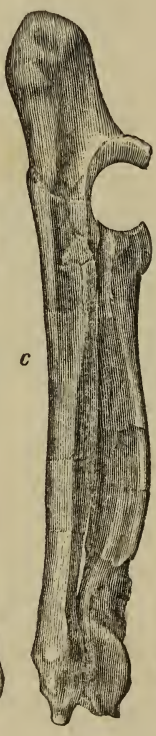


Fig. 8.

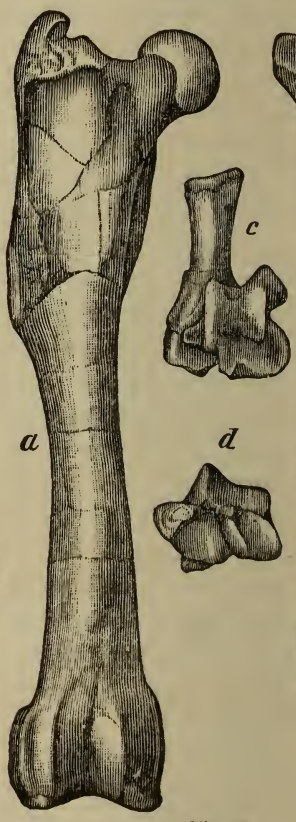


Fig. 9.

FIG. 8.—Anterior limb bones of the specimen of *Mesonyx ossifragus* represented in Figs. 2 and 6, one-third natural size. Fig. *a*, humerus from front; *b*, distal view of distal extremity; *c*, right ulna and radius, external view; *d*, the same from above. FIG. 9.—Posterior limb of *Mesonyx ossifragus*, the individual represented in Figs. 2, 6 and 8, one-third nat. size. Fig. *a*, femur from front; *b*, tibia from front; *c*, astragalus and calcaneum from above; *d*, the same, distal view. From the Big Horn region of the Wasatch epoch.

life in the other bones of its limbs. Its teeth, on the other hand, are of the simple construction of the mammals which have a diet largely composed of fishes. We cannot but consider this animal

as one of the most singular which the Eocene period possessed. In size it was not exceeded by any other flesh-eater of the period, but was equaled by the *Protopsalis tigrinus*. Its anterior limbs were evidently relatively shorter than in the *Mesonyx Janius*.

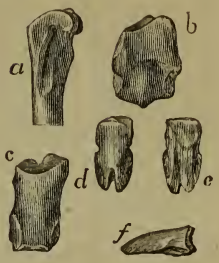


FIG. 10.— Parts of digits of *Mesonyx ossifragus*, one-half natural size. Fig. *a*, metacarpal; *b*, metapodial, distal end; *c*, phalange; *d e f*, an ungual phalange from above, below and side. Original. From the Wasatch beds of Wyoming.

The *Sarcothraustes antiquus* is a large animal from the Puerco epoch of New Mexico, of about the size of the *Mesonyx ossifragus* Its inferior molars have a wide heel as in Amblyctonus. The genus Dissacus Cope occurs in the same formation and locality Its inferior molars (Fig. 11) present an accessory cusp on the inner side of the principal cone. This constitutes the first step towards the tubercular-sectorial tooth of other families. There are two species, the *D. navajovius*, as large as the red fox, and *D. carnifex* Cope, of larger size.

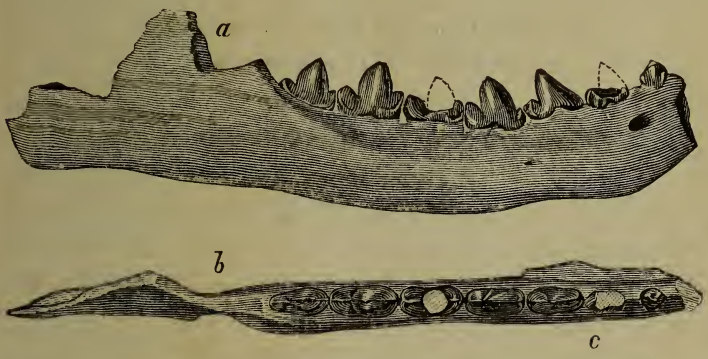


FIG. 11.—*Dissacus navajovius* Cope, right mandibular ramus, three-fourths natural size; *a*, external; *b*, superior views. From the Puerco beds of New Mexico. Original.

(*From the American Naturalist, April, 1884.*)

THE CREODONTA.

BY E. D. COPE.

(Continued from the March number, p. 267.)

HYÆNODONTIDÆ.

IN this family the anterior cusp of the inferior true molars is so developed as to form, with the median cusp, a true sectorial blade. The posterior cusp is rudimental, and in the last inferior molar wanting. There is no internal tubercle. In the superior molars, on the contrary, the anterior basal cusp has disappeared, and the posterior one is developed behind the middle one, like a blade. The superior molars, like the inferior, have no internal lobe.

Professor W. B. Scott has studied the posterior limb and the brain-case of a species of Hyænodon, which he describes as follows. I quote from the advance sheets of his paper on this subject, which he has kindly permitted me to use:

"The hind limb is in essentials very like that of Mesonyx of the Bridger Eocene; the femur has a decided third trochanter. The tibia is much like that of Mesonyx, and its distal end is characteristically Creodont in having its astragalus face almost

flat, with only a very slight median ridge for the groove of the astragalus. The internal malleolus is very large.

"The astragalus is but slightly concave from side to side, much less so than in Mesonyx.

"The foot is plantigrade, and the entire length of the calcaneum rested on the ground. Five well-developed digits were present, terminating in short and stout compressed claws; very different from the peculiar depressed ungual phalanges of Mesonyx; otherwise the resemblance of the foot as a whole to that of Mesonyx is very striking.

"The brain case attributed by Gervais to Hyænodon must belong to some other genus, or else our American species differ very radically from the French. In the American species the brain is relatively very small and simple, being but slightly larger than that of Thylacynus, to which animal Hyænodon presents many interesting approximations in the structure of the skull and teeth. The cerebellum of Hyænodon is entirely uncovered by the hemispheres, which in their turn seem to have but three straight longitudinal gyri, presenting the simplest type of the carnivorous brain."

It is highly probable that this family is a derivative of a pentadactyl form of the Mesonychidæ. Its appearance in time corresponds nearly with the disappearance of the latter.

But one genus of this family has been thus far described, the Hyænodon of Laizer and Parieu. Its dental formula is I. $\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{3}{4}$; M. $\frac{3}{3}$. The last three molars in both jaws are sectorials, and the last of these are the largest, and form the most effective shears for the dividing of animal tissues. The position of these teeth indicates a mouth fissured far posteriorly, and a correspondingly posterior position of the masseter muscle. This structure indicates a weak power of prehension of the canine teeth. This character is sustained by the frequently anteriorly directed inferior canines, and the generally slender mandibular rami. The Hyænodons must be regarded as snappers, and not capable of holding on to a living enemy with much persistency.[1] They were evidently weaker in all points of organism than the modern Carnivora, which no doubt accounts for their extinction. Thirteen species have been described, all but three North American forms being French. The oldest of these, the *H. parisiensis* Kefst., is from the Upper Eocene or Oligocene, or the Paris Gypsum, but its reference to this genus is not yet certain. Gaudry, however,

[1] See On the origin of the sectorial tooth of the Carnivora, AMERICAN NATURALIST, 1876, p. 171.

states that Hyænodon occurs in the Gypse. Seven species are described by Filhol as from the Phosphorites. Some of these (as *H. leptorhynchus* L. & P.) are elsewhere found in the Stam-

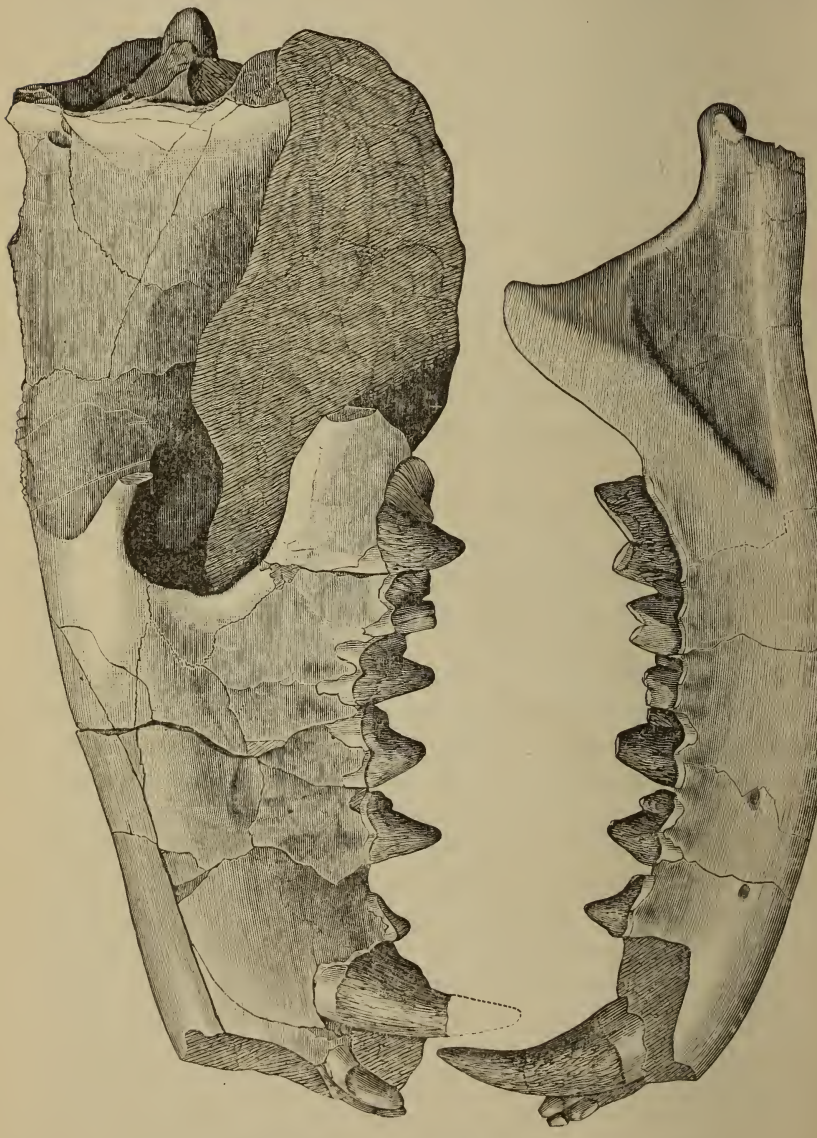


FIG. 12.—*Hyænodon horridus* Leidy, skull one-half natural size. From the White River formation of Nebraska. From Leidy's Extinct Mammalia of Dakota and Nebraska.

pian, a Lower Miocene, but some of them are probably Upper Eocene.[1] The three North American species are from the White

[1] Professor Gaudry thinks the Phosphorites include fossils of different Tertiary epochs.

River or Oligocene horizon, and no species is known from later formations. The species range in size from that of the *H. vulpinus* Gerv., which equals a red fox, to that of an American black bear, as the *H. heberti* Filhol, and *H. horridus* Leidy (Fig. 12). The latter species is from the bad lands of Nebraska.

Leptictidæ.[1]

This family is very nearly related to the Centetidæ, which are now living in Madagascar. The only character by which I dis-

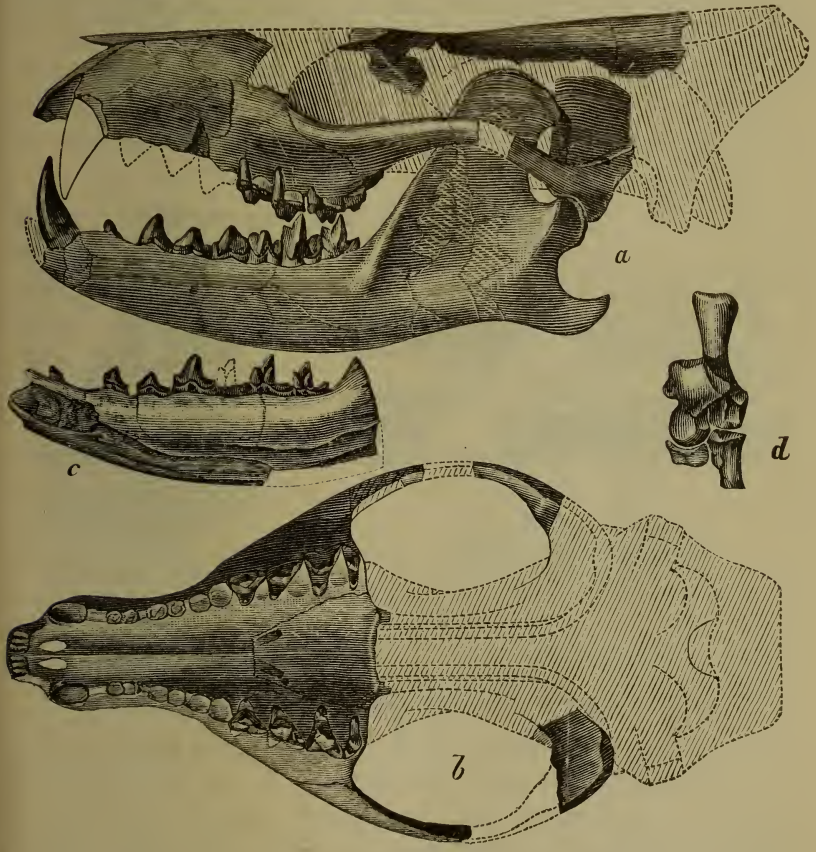


Fig. 13.—*Stypolophus whitiæ* Cope, skull and part of posterior foot of two individuals, two-thirds natural size. Figs. *a–b* from the Wasatch beds of the Big Horn river, Wyo. Figs. *c–d* from the basin of the Wind river, Wyo. Fig. *c*, internal side of part of right mandibular ramus. Fig. *d*, left tarsus minus cuneiform bones, from above. Original, from Vol. III, Report U. S. Geological Survey Terrs., F. V. Hayden.

tinguish it is by the presence of the zygomatic arch, a part of the skull which is absent in the Centetidæ (Fig. 13). The Leptictidæ

[1] This family is included in the Centetidæ in the first part of this paper, p. 261.

are no doubt the ancestors of the Centetidæ; and their later types, as Leptictis, approach the existing family in their dentition quite closely.[1] The earlier types display great variety in their dentition, and give ground for distinguishing many genera.

Two groups are easily recognized among the Leptictidæ. In the first of these the last or fourth inferior premolar is a simple premolariform tooth, different from the inferior true molars, and without any internal cusp. In the second division the fourth inferior premolar is either like the true molars or approximates their form by the presence of an internal tubercle. To the latter group belongs the genus Chriacus, which from the slight development of the fourth inferior premolar (Fig. 14) approximates the first division. The genus may, however, be improperly referred to the Creodonta.

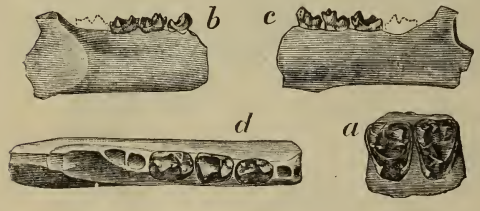


Fig. 14.

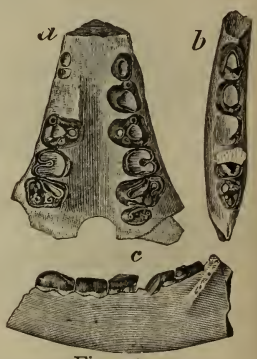


Fig. 15.

FIG. 14.—*Chriacus angulatus* Cope, right ramus of mandible and part of maxillary bone with teeth; from the Wasatch beds of the Big Horn, Wyoming. Figs. *a* and *d* twice natural size. Figs. *b–c* natural size. Fig. *a*, first and second true molars from below; *b*, ramus from external side; *c*, the same, internal side; *d*, the same from above. FIG. 15.—*Mioclænus turgidus* Cope, part of skull and lower jaw of one animal, two-thirds natural size. From the Puerco beds of New Mexico. Original, from Vol. III, Report U. S. Geol. Survey Terrs.

There are seven genera of the first division of the family. These may be distinguished into two sections. In one of these there are three well-developed anterior cusps of the inferior true molars, forming a tubercular sectorial tooth; in the other the anterior

[1] Enough is now known of the mammalian fauna of Madagascar to convince us of its decidedly Miocene and, to some degree, Eocene character. The lemurs and Centetidæ approximate nearly the Eocene types; the Chiromys is near the Eocene Tillodonta, while the closest allies of the carnivorous genus Cryptoprocta are found in the Lower Miocene of France and the Middle Miocene of Oregon. The Oligocene descendants of the Eocene types appear to have persisted in Madagascar. The reptiles are not African but are South American.

cusp is rudimental or wanting, and the tooth approximates more or less the quadrituberculate condition. In the latter subsection there are three genera. The first of these, Mioclænus Cope, has the inferior true molars quadrituberculate and of equal elevation; the first true molar may have an anterior or fifth tubercle. The external cusps of the superior true molars are distinct and conical. In Triïsodon Cope, the inferior true molars only are known. These have four cusps with a rudimental anterior fifth. They differ from the corresponding cusps in all the other genera in being compressed so as to have fore and aft cutting edges. Diacodon Cope, is the third genus. Its superior molars are like those of Mioclænus, but the two anterior cusps of the lower true molars are much elevated, the posterior are rudimental, and there is a rudimental fifth in front.

Mioclænus presents the only truly quadritubercular lower molars in the suborder. It is so far known only from the Puerco or oldest Eocene of North America. There are nine species known

Fig. 16.

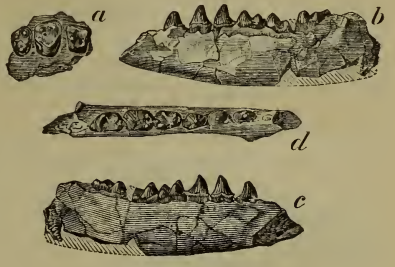


Fig. 17.

FIG. 16.—*Mioclænus corrugatus* Cope, last four molars on maxillary bone from below, two-thirds natural size. From the Puerco beds of New Mexico. Fig. *a*, from below; *b*, from right side. FIG. 17.—*Mioclænus subtrigonus* Cope, parts of maxillary and mandibular bones two-thirds natural size; from the Puerco beds of New Mexico; *a*, superior true molar teeth from below; *b*, left mandibular ramus, external side; *c*, do. inner side; *d*, from above. From Report U. S. Geol. Survey Terrs., Vol. III.

so far, which range from the size of a mink (*M. minimus*) to that of a wolf (*M. ferox*) in the sizes of their jaws, but in the case of the *M. ferox*, of which a good deal of the skeleton is known, the body was relatively smaller. The species differ in the form of the third superior premolar, and in the robustness of their inferior premolars. The *M. turgidus* (Fig. 15) represents the type with robust premolars, and the *M. subtrigonus* (Fig. 17) those with more compressed premolars.

We can read the nature of the primitive mammal, *Mioclænus ferox*, in so far as the materials permit. It was an effective flesh-eater, and probably an eater of other things than flesh. It had a long tail and well-developed limbs. It had five toes all around, and the great or first toe was not opposable to the others, and may have been rudimental. The feet were plantigrade and the claws prehensile. The fore feet were well turned outwards. There were, perhaps, marsupial bones, but this point is not yet certainly determined. The presence of a patella distinguishes it from marsupials in general. Its embracing glenoid cavity of the skull, and form of the inferior molars, resemble those of the Arctocyonidæ.

This species is about the size of a sheep. The bones are stated by Mr. Baldwin, who discovered it, to be derived from the red beds in the upper part of the Puerco series.

The genus Triïsodon includes as yet but one species, the *T. quivirensis* Cope, which is only known from the rami of the lower jaw. These bones are shorter and more robust than those of the coyote, and indicate an animal of perhaps the size of the wolverine (Fig. 1, p. 257). It was evidently strongly carnivorous in its diet, and was a capable biter. Its remains are from the Puerco of New Mexico.

Diacodon includes seven species, two from the Wasatch Eocene, the others from the Puerco. The former are much the smaller (Fig. 18), while those of the Puerco vary in dimensions from the size of a common weasel (*D. assurgens*) to that of a wolf (*D. conidens*). The five species of the Puerco were formerly referred by me to the genus Triïsodon, but are now more properly placed in Diacodon. The only species in which the superior molars are known is the *D. conidens*, where they are generally identical with those of Mioclænus.

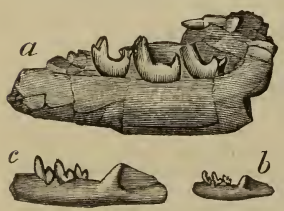


FIG. 18.—Jaws of species of Diacodon from the Wasatch bed of New Mexico. Fig. *a*, *Diacodon alticuspis* Cope, right mandibular ramus, inner side, twice natural size. Fig. *b*, *D. celatus*, left mandibular ramus, natural size; *c*, same, twice natural size. Original, from the Report U. S. G. G. Surv. W. of 100th mer., G. M. Wheeler.

Of the four genera of the first division of the Leptictidæ, which possesses tubercular sectorial teeth, but two are found in North America, while three of them have been discovered in Europe.

The typical and most widely distributed genus is Stypolophus

Cope (Fig. 13). It has compressed premolars, except the fourth superior, which is conic with two basal lobes. In Proviverra Rütimeyer, this tooth is triangular and cutting. One species has been found in the Swiss Eocene. Quercitherium of Filhol is distinguished by its very robust premolars. Like Proviverra it has but one rather small species. It is from the French Phosphorites. Stypolophus has the two cusps of the superior true molars close together, forming twin cusps, and they have behind them a heel, which is cutting. Two species have been discovered in the French Phosphorites, one of which, the *S. caylusi* of Filhol, is preserved to us in the most perfect skull of a Creodont known. From it I have restored the skull of the *S. whitiæ* (Fig. 13). It has elevated sagittal and posterior crests for the insertion of the temporal muscles, and the brain-case is very small. A cast of the brain displayed to Mr. Filhol the following characters: The hemispheres are small, and leave the cerebellum and the posterior edge of the middle brain uncovered. Anteriorly they contract to an isthmus which separates them from the large olfactory lobes. The hemispheres display three longitudinal convolutions, and very little indication of sylvian fissure. Of the American species, five are known from the Wasatch, and four from the Bridger beds.

Nearly allied to Stypolophus is the genus Didelphodus Cope, which only differs from it in the possession of but three superior premolars. The single species, *D. absarokæ* Cope, is about the size of a skunk, and has been obtained in the Wasatch Eocene beds of the Big Horn river, Wyoming (Fig. 19).

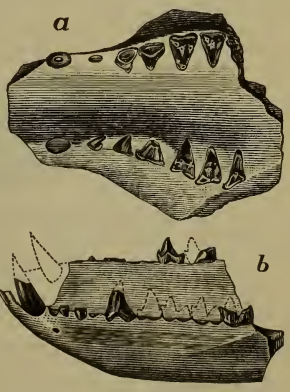


FIG. 19.—*Didelphodus absarokæ* Cope, muzzle and corresponding part of mandible of one individual, natural size. Original, from Vol. III, Report U. S. Geol. Surv. Terrs.

There are six genera of the second section of the family Leptictidæ, *i. e.*, those with the fourth inferior premolar more or less like the true molars. In five of these genera the canines and incisors have the proportions usual in carnivorous animals, but in the sixth, Esthonyx Cope, the canines are smaller than some of the incisors. In this respect Esthonyx esembles some of the genera of

Centetidæ, and other recent families both of Creodonta and Insectivora (Fig. 23). Of the genera with large canines, Chriacus has already been mentioned as having a simple fourth premolar with only an internal cusp to distinguish it from the genera of Sect. 1 of the family. Its true lower molars have an anterior V of three connected cusps. This is also the character of the inferior molars and fourth premolar of Deltatherium (Fig. 20), which is also peculiar in having but $\frac{3}{3}$ premolars, and a diastema. In the three genera which remain, the anterior or

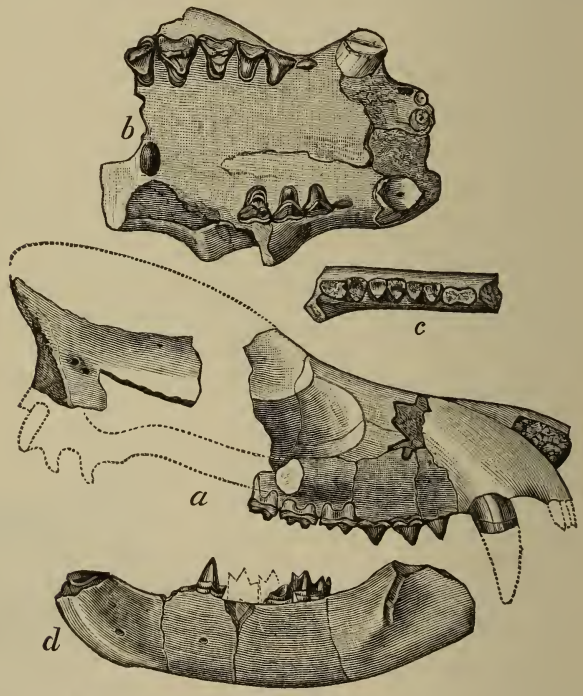


FIG. 20.—*Deltatherium fundaminis* Cope, skull and ramus mandibuli, two-thirds natural size, from the Puerco beds of New Mexico. Figs. *a b c* from one individual; Fig. *d* from a second animal. Fig. *a*, right side of cranium; *b*, palate, from below; *c*, mandible, part, from above; *d*, left ramus, outer side. From the Report U. S. Geol. Survey Terrs., Vol. III. Original.

fifth cusp of the true molars is rudimental. They differ from each other in the structure of the third superior premolar. In Ictops Leidy, this tooth has two external and one internal cusps; in Mesodectes Cope, there are one external and one internal cusps, and Leptictis Leidy, there is no internal cusp, and the external one is simple.

There are certainly three, and probably four, species of Chri-

acus The typical and largest species, *C. pelvidens* Cope, is from the Puerco Eocene of New Mexico; the smallest species, *C. angulatus* Cope, is from the Wasatch beds of New Mexico and Wyoming (Fig. 14). Perhaps it is near this genus that Tricentes Cope, should be placed. The latter only differs from Chriacus in the possession of but three superior premolars.[1] I have suspected that it belongs near Microsyops and Mixodectes in the Lemuroid series. There are three species, none larger than a skunk. The type, *T. crassicollidens*, is known from parts of two crania. The *T. inæquidens* was not larger than a gray squirrel.

The *Deltatherium fundaminis* Cope (Fig. 20), is one-half larger than the Virginian opossum, and much more robust. Its molar teeth are very opossum-like, while its canine teeth are relatively larger and stouter. The crowns of the canines are especially effective as weapons, from their vertical direction and form, their sharp anterior and posterior cutting edges, and their sides grooved like many blood-letting instruments. The sagittal crest is high, and the muzzle is short and wide, so that a decidedly bull-dog expression belonged to this animal. It is the most specialized form of the family and of the Puerco epoch, and was one of the most abundant. There are two other less known species of Deltatherium.

[1] See Proceeds. American Philosoph. Society, 1883, p. 315.

(*From the American Naturalist, May, 1884.*)

THE CREODONTA.

BY E. D. COPE.

(Continued from the April number, page 353.)

THE genus Ictops is found from the Bridger epoch up into the Oligocene or White River Miocene. It thus has much the range of the genus Hyænodon. There are three species, of which I give a cut (Fig. 21) of the *I. bicuspis* Cope, from the Wind River beds of

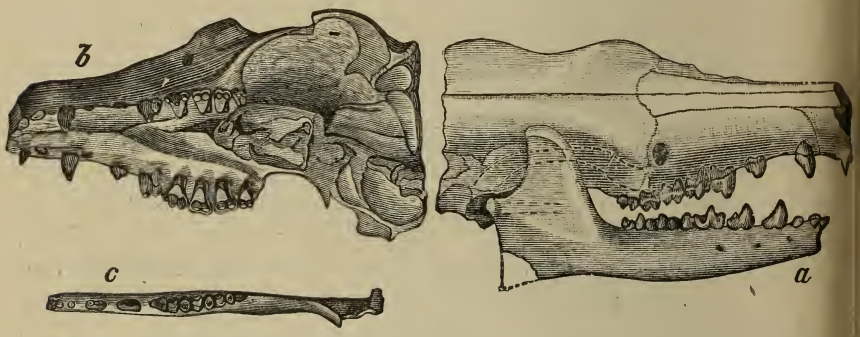


FIG. 21.—*Ictops bicuspis* Cope, skull, natural size. Fig. *a*, oblique view of right side; *b*, do. of inferior side, injured posteriorly; *c*, mandibular ramus from above. From the Wind River Eocene, Wyoming. Original, from Report of U. S. Geol. Survey Terrs., Vol. III.

Wyoming. In this form, as in Leptictis, the incisors and canines are spaced. The White River species is the *Ictops dakotensis* Leidy. But one species of Mesodectes is known, the *M. caniculus* Cope, from the White River beds of Northeastern Colorado I discovered a good deal of its skeleton, which furnishes an idea of its general characters. Its skull, like that of the *Leptictis haydeni* Leidy, possesses the marsupial character of a subsquamosal foramen (Fig. 22 *ss*), but the resemblance to this order includes besides only the dentition. There is a large keeled præsternum, stouter and shorter than that of a mole, suggesting a burrowing habit, but the humeri are not robust. The neck is very short, and the cervical vertebræ are without neural spines. The cerebral hemispheres of the brain leave the olfactory lobes and the cerebellum entirely exposed, and are wide and short. They are smooth, but the sylvian fissure is visible. This animal was about the size of the European hedgehog (*Erinaceus europæus*).

As yet but one species of Leptictis is known, the *L. haydeni*

Leidy (Fig. 22). This animal has been found in the White River beds of Nebraska. It is about the size of the *Mesodectes caniculus*. It resembles the gray fox of North America in the rib-like temporal ridges of its skull.

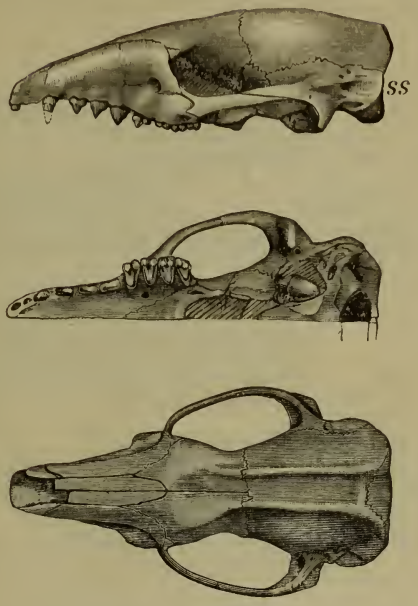


FIG. 22.—*Leptictis haydeni* Leidy, skull, natural size, from the White River beds of Nebraska. From Leidy, Extinct Mammalia of Dakota and Nebraska. *ss*, subsquamosal foramen.

The remarkable genus which I have called Esthonyx, is exceptional in the family in the large development of its second inferior incisors at the expense of the others. One or more of the superior incisors has been supplanted by the large development of the one that remains. The canines are moderately reduced, and the premolars are $\frac{3}{3}$ (Fig. 23). The last premolars of both jaws are more or less like true molars. The inferior true molars support two V's, of which the anterior is the more elevated. A good deal of the skeleton of the *E. burmeisteri* Cope, is known. Its distinct scaphoid and lunar bones are represented in Fig. 24 *b b'*. It had five digits in the manus. The cervical vertebræ are more robust than the dorsal, and the tail is long and large. The characters of this genus approximate it to the true hedgehogs (Erinaceus), and I formerly placed it in the same order. The tritubercular superior molars separate it widely. Nevertheless I suspect that it stands in ancestral relation to the Erinaceidæ.

I have described five species of this genus, of which two are from the Wasatch of New Mexico, two from the corresponding beds of Wyoming, and one, *E. spatularius*, from the Wind River bed of Wyoming. *E. acutidens*, of the Big Horn region, is the largest, equaling a red fox in the size of the skull. The skeleton of *E. burmeisteri* shows, however, that, as in other Creodonta, the

limbs are smaller in relation to the skull than in modern Carnivora. The least species is the *E. acer* of New Mexico.

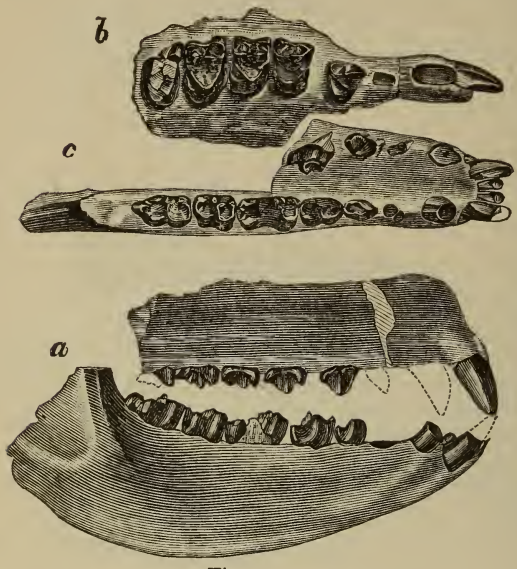


Fig. 23.

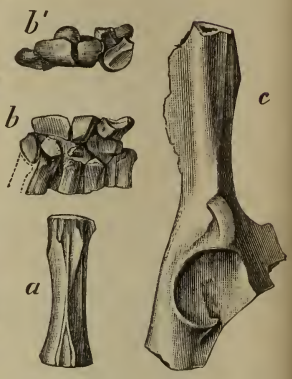


Fig. 24.

FIG. 23.—*Esthonyx burmeisteri* Cope, part of skull with lower jaw, from the Wasatch epoch of the Big Horn, Wyoming. two-thirds natural size; Fig. *a*, lateral view; *b*, inferior; *c*, superior views. The superior jaw consists of two pieces. FIG. 24, bones of specimen represented in Fig. 23, same proportions. Fig. *a*, caudal vertebra; *b*, carpus from front; *b'*, do. proximal view; *c*, part of innominatum, external view. Original, from the Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III.

OXYÆNIDÆ.

The genera of this family are best explained by the following analytical table. The pertinence to it of the genus Thereutherium Filh., is not certain. The only genera which present the character of the narrow transverse third superior true molar, are Oxyæna and Pterodon.

I. Inferior molars with three anterior cusps.

Cusps obtuse; fourth premolar with tubercular heel; formula $\frac{3}{3}\ \frac{3}{3}$.....*Palæonyctis*.[1]
Cusps acute; heel of fourth premolar cutting; formula $\frac{3}{4}\ \frac{3}{2}$.....*Oxyæna*

II. Inferior molars partly tubercular-sectorial, partly sectorial.

Superior molars unknown.....*Protopsalis*.

[1] These characters are derived from an examination of the type of DeBlainville, preserved in the Mus. Jardin des Plantes, which the permission of Professor Gervais enabled me to make. Other characters of the fourth premolar, which I have hitherto copied from others, are inexact.

III. Inferior molars sectorial.

Last superior molars transverse; others with two median cusps; formula $\frac{3}{3}$ $\frac{3}{3}$, *Pterodon.*

Last superior molar subround; others with one median cusp; formula $\frac{3}{4}$ $\frac{3}{2}$, *Thereutherium.*

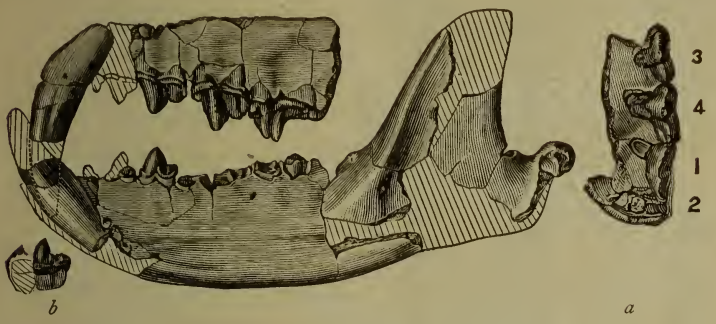


FIG. 25.—*Oxyæna lupina* Cope, jaws, one-half natural size, from the Wasatch beds of New Mexico. Fig. *a*, maxillary bone with teeth, from below; *b*, last superior molar, from behind. Original from the Report U. S. G. G. Survey W. of 100th mer., G. M. Wheeler.

Of the above genera Oxyæna and Protopsalis only are American. Thereutherium Filhol, includes a species, *P. thylacoides*, with a skull of the size of that of a skunk, which has been obtained from the Phosphorites of France. There are two species of Pterodon, both robust flesh-eaters. The *P. dasyuroides* of De Blainville is one of the longest known of the Creodonta. The *Palæonyctis gigantea* Blv., is found in the plastic clays near Paris. Its dentition approaches that of Amblyctonus.

The Oxyænas have the characteristic peculiarities of the Creodonta and of the carnivorous marsupials in their general proportions. The head was relatively larger, and the limbs were smaller than in true Carnivora. The feet were plantigrade, and had five toes anteriorly and posteriorly. The hind foot was either divided so that the external two toes opposed the internal three, or were divergent and connected by a median web. If not divided, the entire foot was directed outwards from the line of the calcaneum. In the latter case the hallux may have been opposable, as in the opossum, but in a much less degree. The tail was long and stout (Fig. 26).

Species of this genus were abundant during the Wasatch epoch in New Mexico and Wyoming, and probably over the entire continent. They have not yet been reported from higher Eocene beds, not even occurring in the Wind River. A small species is

found in the Puerco. A species (*O. galliæ*) has been recently detected in the Eocene of France by M. H. Filhol.

The dentition of the Oxyænas indicates sanguinary habits (Fig. 25). From the measurements, which are confirmed by more than one other skeleton, it can be seen that there is in the *Oxyæna forcipata* (Fig. 3, p. 260), a remarkable disproportion between the size of the skull and that of the limbs. While the dimensions of the jaws are like those of the jaguar, those of the limbs do not exceed those of the cheetah, while the digits are not only much shorter, as those of a plantigrade animal, but are more slender. The ungual phalange preserved, shows that the claws had no prehensile power, and were not effective as weapons or for digging. This is a further indication that the species of Oxyæna were aquatic in their habits.

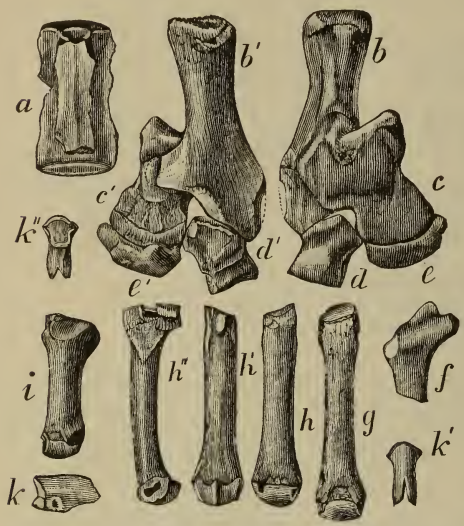


FIG. 26.— *Oxyæna forcipata* Cope, posterior foot and (*a*) caudal vertebra, two-thirds natural size. Figs *b*, calcaneum, *c*, astragalus; *d*, cuboid; *e*, navicular bone; from above; *b' c' d' e'*, the same from below. Figs. *f g h i*, metapodial bones; *k*, ungual phalange from above, right side and below. From the Wasatch beds of the Big Horn, Wyoming. Original, from the Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III.

But one species of the genus Protopsalis is known, the *P. tigrinus* Cope, which shares with the *Mesonyx ossifragus* the distinction of being the largest of the Creodonta. It is from the Wind River beds, which possess a fauna mainly of Bridger character, but with an admixture of Wasatch forms.

The form of the sectorial tooth, together with that of the metatarsal, approximates this genus to the Felidæ more closely than to any other family of existing Carnivora. The resemblance seen in the sectorial (Fig. 27 *a*) is, however, probably delusive, as it is not the same tooth as the sectorial of the Carnivora. The resemblance in the metatarsal is real, as the characters are unlike those of Canidæ or Hyænidæ. The feet are evidently larger than in many of the Creodonta, as the proximal extremity of

the metatarsal is as large as that of a lion.

It is possible that the genus Patriofelis of Leidy belongs to this family, but its dental characters are not described with sufficient precision to enable this question to be decided. The inferior molar series is short, including, according to Leidy, only five teeth. The *P. ulta* Leidy, has a jaw the size of the puma. It is from the Bridger beds of Wyoming.

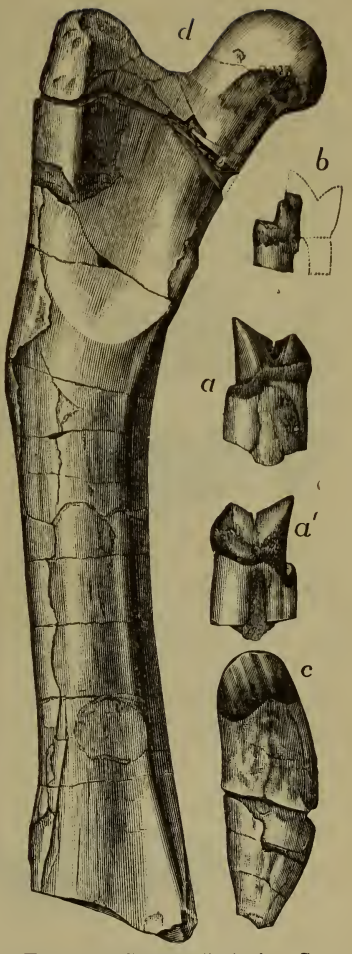


FIG. 27.—*Protopsalis tigrinus* Cope, one-half nat. size. Fig. *a*, probably last inferior molar, innerside; *a'*, external side; *b*, penultimate inferior molar, inner side; *c*, inferior canine, external side; *d*, femur, anterior view. From the Wind river of Wyoming. Original, from Report U. S. G. Survey Terrs., III.

MIACIDÆ.

In this family we have the point of nearest approximation of the Creodonta and Carnivora. This is indicated by the fact that the sectorials of this family are true sectorials, both by position and form, such as are not elsewhere met with in the Creodonta. The genera might readily be taken for members of the Canidæ and Viverridæ, but for the structure of the astragalus, which is thoroughly Creodont. There is no trochlear groove of the tibial face, and in Didymictis it is so oblique that the internal malleolar face looks partly upwards. There are two genera known, Miacis Cope, with two inferior tubercular molars, and Didymictis Cope, with but one.

Five species of Miacis have been described, two of which are from the Wasatch and three from the Bridger beds. The former are distinguished from the latter by the larger size of the second tubercular molar, which has two roots. The later species, of which the type *M. parvivorus* Cope, is one, have but one such

root. None of the species exceeded the gray fox in size, and the Bridger species at present known, are much smaller.

Didymictis has a greater range in time than Miacis. Eight species have been described, two of which are from the Puerco horizon and six from the Wasatch. The genus is probably represented by other species in the Bridger. There are three divisions of the genus. In the first the premolars are not lobed on their posterior margins; here belong *D. primus* and *D. haydeni-*

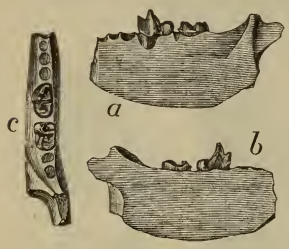


Fig. 28.

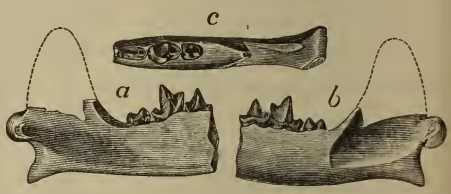


Fig. 29.

FIG. 28.—*Miacis brevirostris* Cope, left mandibular ramus, two-thirds natural size. Fig. *a*, left side; *b*, inner side; *c*, from above. From the Wasatch beds of the Big Horn. FIG. 29.—*Didymictis massetericus* Cope, left mandibular ramus, two-thirds natural size, from the Big Horn river, Wyoming. Fig. *a*, inner side; *b*, external side; *c*, superior view. Original, from the Report U. S. Geol. Survey Terrs., Vol. III.

anus (Fig. 30) of the Puerco. The others have the lobes in question, but two of them, *D. curtus* Cope, and *D. massetericus* Cope

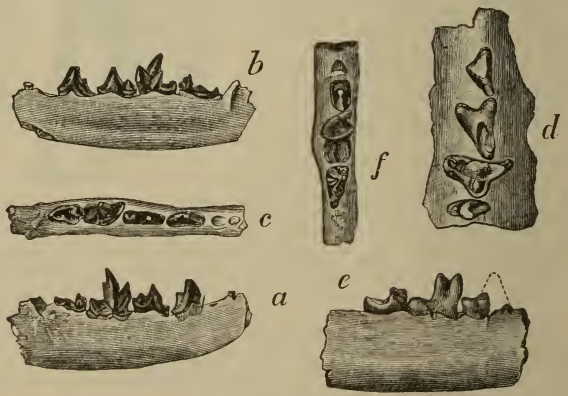


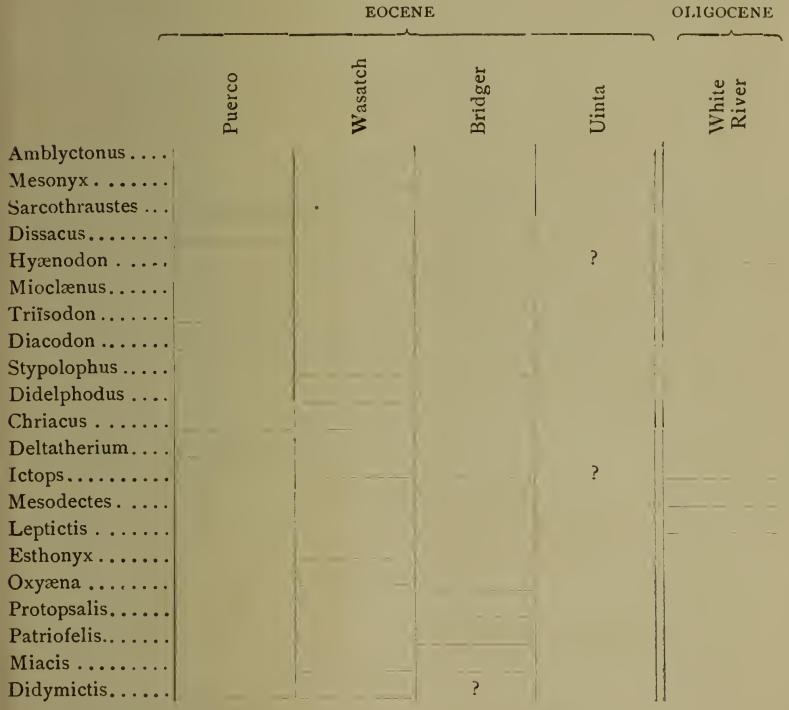
Fig. 30.

FIG. 30.—*Didymictis dawkinsianus* Cope, natural size; from the Wasatch beds of the Big Horn, Wyoming. Fig. *a*, external side; *b*, internal side; *c*, from above. Figs. *d. e, f, Didymictis haydenianus* Cope, jaws natural size, from the Puerco formation of New Mexico. Fig. *d*, maxillary bone with teeth, from below; *e*, left ramus mandibuli, inner side; *f*, do., from above. All original, and from the Report U. S. Geol. Survey, Terrs., F. V. Hayden in charge, Vol. III.

(Fig. 29), have a short subcircular tubercular molar, while that of

the other species is an elongate oval. The tendency in the genus has been to complicate the premolars and shorten the tubercular in the course of time. The smallest species is the *D. dawkinsianus* (Fig. 30), from both the Big Horn and Wind River beds, an abundant and acute-toothed species. The largest species is the *D. altidens* Cope, whose jaws are more robust than those of the coyote.

I append the following table showing the distribution of the genera of Creodonta in the North American Tertiary formations:



PRINTED April 24, 1884.

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(*From the American Naturalist, May, 1885.*)

THE

LEMUROIDEA AND THE INSECTIVORA

OF THE

Eocene Period of North America.

BY E. D. COPE.

PRINTED APRIL 15, 1885.

(*From the American Naturalist, May, 1885.*)

THE LEMUROIDEA AND THE INSECTIVORA OF THE EOCENE PERIOD OF NORTH AMERICA.

BY E. D. COPE.

TWO distinct divisions are included in this article, because the material is not yet sufficiently complete to enable me to refer certain forms to the one rather than the other. The only characters on which the osteologist can rely in endeavoring to distinguish the two groups are these: First, the terminal phalanges of the Insectivora are compressed and curved, forming claws; while those of the Lemuroidea and of most other Primates are more or less flat, and at the extremity rounded and depressed,[1] or more or less like hoofs.[2] Second, the hallux or inner toe of the posterior foot is opposable to the others, a character dependent on the form of the entocuneïform bone of the tarsus, which has in that

[1] See AMERICAN NATURALIST, April, 1885, where the Condylarthra are referred, with the Quadrumana, to the Ungulata.

[2] The marmosets are exceptions, having true claws.

case a rounded distal extremity, forming part of a cylinder directed more or less fore and aft, for articulation with the metatarsus or proximal element of the great toe. In the Insectivora this structure is wanting, the inner toe being fixed in a position parallel with the others as in the Carnivora. In the Lemuroidea the position of the thumb or pollex is less different from what is seen in the Insectivora, than is the case with the posterior foot. In the true lemur the thumb is but little opposable, except in the genus Chirogaleus and some others. The distal end of the trapezium bone of the carpus with which the thumb articulates, does not form a part of a cylinder in the Lemur or in the Tarsius. When the thumb becomes opposable in the monkey proper, the thumb facet of the trapezium is not rounded, but is wide and a little concave. It is not till we reach the man-like opposable thumb of the anthropoid apes that we find this bone presenting to the thumb a semicylindrical face like that of the entocuneiform bone of the posterior foot.

The Condylarthra as I have pointed out,[1] must be regarded as a division of the order of Taxeopoda, along with the Hyracoidea, the lemurs, the monkeys and man. The difference between the hoofs of Phenacodus and the ungues of Lemur is too slight to admit of wider separation: and the other parts of the structure show an equal agreement. There is no trace of opposability of the hallux in Phenacodus however, nor any os centrale of the carpus, characters which show that the suborder Condylarthra and Lemuroidea are distinct. In the pollex or thumb of Phenacodus, however, there is a distinct indication of opposability, though it is not so well developed as in the genus Lemur. The basal articulation with the trapezium is narrow, but is directed partly fore and aft, so that the thumb looks inwards. Its power of flexure at the base has been slight, but the flexure at the base of the first phalange has been such as to make the end of the thumb quite opposable.[2] From the Condylarthra then we trace the order Quadrumana on the one hand, and the hoofed orders on the other.

In the following pages I will not attempt to distinguish which of the genera are lemuroid and which are insectivorous, since the ungual phalanges are yet unknown. An exception must be made in the case of the genus Pelycodus, where a single compressed

[1] NATURALIST, April, 1885. Primates and Taxeopoda are there regarded as nearly synonymous.

[2] See NATURALIST, 1884, Plate XXIX, for the skeleton of Phenacodus.

acute claw is known. This alone does not decide the question, since such a claw exists on the second toe of many Lemuroidea.

These animals are readily distinguished into three divisions or families by the number of their premolar teeth. There are four such teeth in the Adapidæ; three in the Mixodectidæ, and two in the Anaptomorphidæ. In the Adapidæ we have the most primitive type, and the one most nearly allied to the Condylarthra, from which they were probably derived. In the Mixodectidæ we have the dental formula of the existing lemurs, with a tendency in some of the genera to develop large cutting teeth in the position of incisors, thus approaching the aye-aye. In the Anaptomorphidæ, on the other hand, we find a dental formula like that of the Simioidea and Anthropoidea, or higher

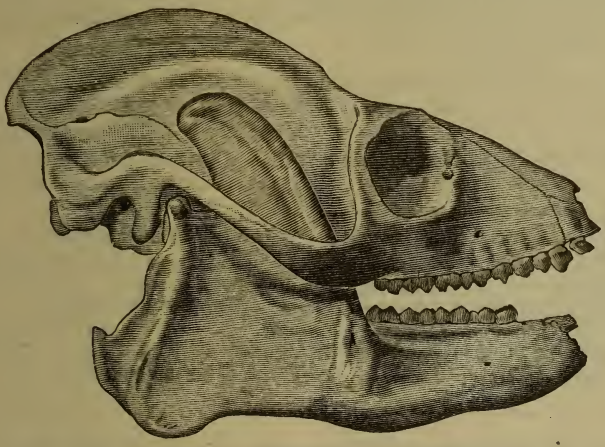


FIG. 1.—*Adapis parisiensis* Cuv., skull nat size, from the Phosphorites of Central France. From Filhol.

monkeys and apes; and in them we seem to get a hint of the derivation of these higher forms, and of man himself.

The genera of the Adapidæ are distinguished by various dental characters. Such are the presence of a second anterior-inner cusp of the inferior true molars; the presence of an internal cusp of the fourth inferior premolar; the number of incisor teeth, and number of single-rooted premolars. The difference between the quadrituberculate and the quinquetuberculate inferior molar may be understood by reference to Fig. 2, where the teeth of the genera Hyopsodus (*a*) and Microsyops (*b*), which represent the two types, are placed side by side.

In some genera, (Notharctus, Tomitherium, Figs. 4–5) the fifth cusp is present but weak. In others (Sarcolemur) it is repre-

sented by the anterior lobe of a twin or fissured anterior inner

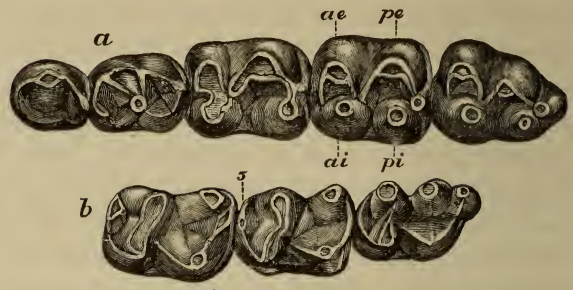


FIG. 2.—Inferior molar teeth of (*a*) *Hyopsodus paulus* Leidy, and (*b*) *Microsyops gracilis* Marsh; enlarged four times linear, from above. Fig. *ae*, anterior external cusp; *pe*, posterior external cusp; *ai*, anterior internal and *pi*, posterior internal cusp; 5 fifth or second anterior internal cusp. From Leidy, Report U. S. Geol. Surv. Terrs., F. V. Hayden in charge, Vol. I.

cusp. To simplify the understanding of these differences, I give the following table:

I. Inferior molars qadrituberculate.

Fourth inferior premolar with internal cusp: cusp on last molar opposite
Hyopsodus Leidy

Fourth inferior molar without internal cusp; cusps opposite .....*Apheliscus* Cope.[1]
Cusps of last molar alternate.....*Opisthotomus* Cope.

II. Inferior molars quinquetuberculate.

a. Anterior triangle not well developed on inferior molars.

Fifth cusp separated from anterior inner by an apical fissure only..*Sarcolemur* Cope.
Fifth cusp separated; canine distinct; one premolar one-rooted..*Notharctus* Leidy.
Fifth cusp well separated; canine distinct; two premolars one-rooted
Tomitherium Cope.
Fifth cusp separated, low; canine incisor- or premolar-like.....*Adapis* Cuv.

aa. Anterior triangle well developed on all the inferior molars.

Canine distinct; one premolar one-rooted.....*Pelycodus*[1] Cope.

Jaws of four species of Hyopsodus are abundant in the Wasatch and Bridger Eocene beds, and a species from the Puerco has been doubtfully referred to it. The best known species, the *H. paulus* Leidy (Fig. 2), of the Bridger epoch, has the jaws as large as those of a rabbit. The *H. vicarius* Cope, was smaller (Fig. 3). Nothing is known of the skeleton of any species of Hyopsodus. The only species of Apheliscus (*A. insidiosus* Cope) was found in the Wasatch beds of New Mexico. It has large teeth in the position of sectorials, and may be an aberrant Creodont. Nothing is known of it but jaws. Two species

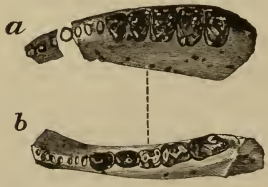


FIG. 3.—*Hyopsodus vicarius* Cope, jaws, from the Wind River (? Bridger) Eocene of Wyoming, natural size; *a*, superior, *b*, inferior dental series. Original, from Report U. S. Geol. Surv. Terrs., III.

[1] Of uncertain reference to this family and order.

of Opisthotomus are known from the same horizon and locality, from teeth only. The *O. flagrans* Cope is, with the *Adapis magnus* Filh., the largest species of the family. Sarcolemur Cope includes a single species from the Bridger beds, of the size of the *Hyopsodus paulus*. It has in its sharp dental cusps an effective biting apparatus.

In Notharctus Leidy, the fifth lobe of the true molars begins to be apparent, though it is only present in the first molar, where it is represented by the internal extremity of an anterior crest. The canine in this genus is well developed. Only one species is certainly known.

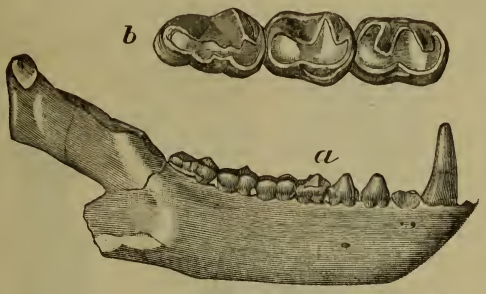


FIG. 4.—*Notharctus tenebrosus* Leidy. *a*, mandible from right side, natural size. Fig. *b*, true molars from above, twice nat. size, linear. From Bridger bed of Wyoming. From Leidy, Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol, I.

More of the skeleton is known in the genus Tomitherium Cope than in any other one of the family, and its relationship to the lemurs was thus indicated at the time of its original description in 1872. Unfortunately the ungual phalanges remain unknown. As in Hyopsodus and Pelycodus, there are but two inferior incisors in the lower jaw, and these have transverse cutting edges, and are not produced as in recent lemurs.

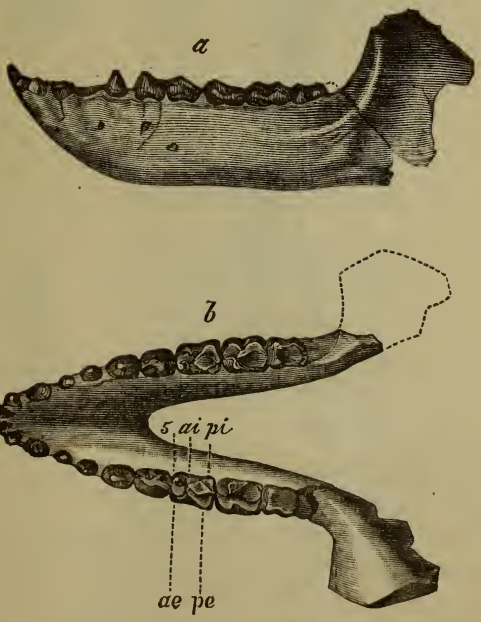


FIG. 5.—*Tomitherium rostratum* Cope, mandible natural size; *a*, from left side; *b*, from above. Letters as in Fig. 2. Original, from Report U. S. Geol. Survey Terrs., Vol. III.

The first impression

derived from the appearance of the lower jaw and dentition, and from the humerus, is that of an ally of the coati (Nasua). The humerus indeed, is almost a fac-simile of that of Nasua, the only difference being a slight outward direction of the axis of the head. The same bone resembles also that of many marsupials, but the flat ilium, elevated position of dental foramen, and absence of inflection of the angle of the lower jaw, etc., render affinity with that group highly improbable.

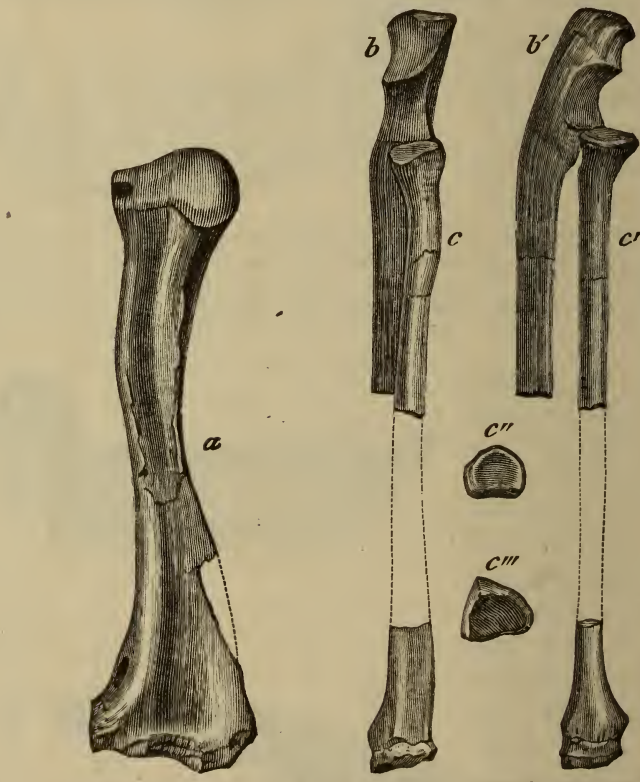


FIG. 6.—*Tomitherium rostratum* Cope, fore leg of animal represented in Figs. 5–7, nat size. Fig. *a*, humerus; *b*, ulna; *c*, radius, from front; *b′*, from side; *c″*, proximal end (artificially flattened below); *c‴*, distal end of radius. From Bridger beds of Wyoming. Original, from Report U. S. Geol. Surv. Terrs., Vol. III.

The length of the femur indicates that the knee was entirely free from the body as in the Quadrumana, constituting a marked distinction from anything known in the Carnivora, including Nasua. The round head of the radius indicates a complete power of supination of the fore foot, and is different in form from that of Carnivora, including Nasua; and, finally, the distal

end of the radius is still more different from that of Nasua, and resembles closely that of monkeys of the genus Semnopithecus.

We have, then, an animal with a long thigh free from the body, a manus capable of complete pronation and supination, and details of lower jaw and teeth quite similar to those of the lower monkeys. The form of the humerus and its relative length to the femur are quite as marked as in some of the lemurs. The most marked difference is seen in the increased number of teeth; but in this point it relates itself to the other Quadrumana, as the most ancient types of Carnivora and Ungulates do to the more modern.

This genus is allied to Adapis Cuvier, of the French Eocene (Fig. 8), but differs in the possession of but two incisors on each side; in Adapis there are three, according to Filhol. From that genus and Opisthotomus, it differs also in the structure of the last inferior molar, as exhibited in the analytical table.

There are several species of Tomitherium, but the

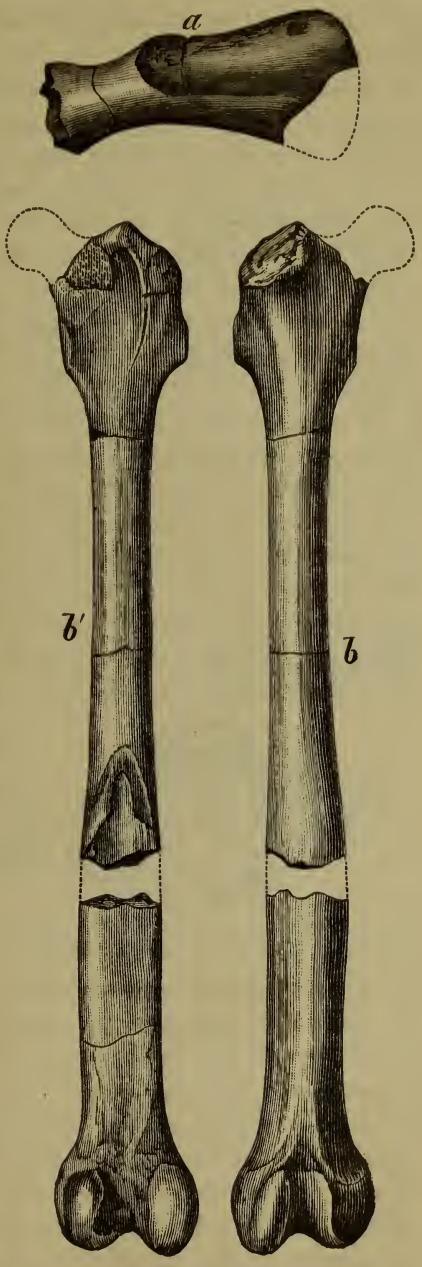


FIG. 7.—*Tomitherium rostratum* Cope, part of animal figured in Figs. 5–6, nat. size. Fig. *a*, ilium inner side; *b*, femur front; *b′*, do. posterior side.

best known is the *T. rostratum* from the Bridger formation of Wyoming.

The following points may be gained by comparison with the skeleton of *Lemur collaris* (catalogue Verreaux). There is considerable resemblance in the details of structure of the molars from the third to the sixth, inclusive. Of course the anterior teeth differ widely in the two, and the last true molar of the Lemur has no heel. The principal difference in the humeri is seen in the superior size of the epicondyles of the *T. rostratum*, and the rather more robust character of the shaft. The proximal half of the ulna is deeper, and the olecranon is not so wide in *T. rostratum*. The proximal part of the radius is very similar in the two species, but the distal extremity is in the *T. rostratum* less transversely extended, and thicker anteroposteriorly. There is also much similarity in the ilia. The crest is more extensive in *T. rostratum*, and the inferior border is thinner at its proximal part. Towards the acetabulum the increase in width of this border is similar, and the anterior inferior spine is as prominent. The resemblance between the femora amounts to identity of character; that of the *T. rostratum* is more robust.

The Mixodectidæ include four and perhaps five genera. In

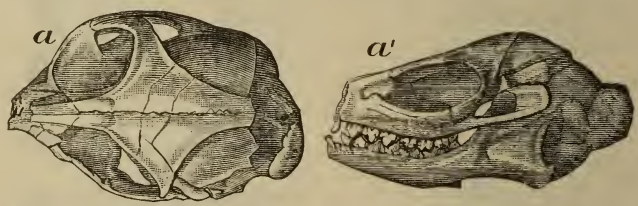


FIG. 8.—*Necrolemur antiquus* Filh., skull natural size, from Phosphorites of Central France. From Filhol Rech. s. les Phosph. de Quercy.

two of these the incisors have their usual position and space. One of these Tricentes Cope, has large canines well separated. It is uncertain whether the genus should not really be referred to the Creodonta.[1] It contains three or four rather small species from the Puerco formation of New Mexico. In Necrolemur the canine is insignificant. One species of the genus, the *N. antiquus* Filhol, is known. It is represented by a cranium in excellent preservation (Fig. 8) which has been fully investigated by Filhol. This able palæontologist regards it as most nearly allied to the genus Galago now existing in Africa. It furnishes conclusive evidence of the former existence of lemurs in France.

[1] See NATURALIST, 1884, p. 353.

Of the three genera with very large incisor (? canine) teeth, Mixodectes has the last lower premolar with a simple cusp. There are two species from the Puerco beds. The smaller of these, *M. pungens* Cope (Fig. 9), is about the size of the kit fox. Its premolars are of irregular size. In the two other genera the fourth premolar has a second cusp on the interior side of the principal one. Both have the crowns of the inferior true molars composed of two triangles as in Mixodectes and Pelycodus. In Microsyops Leidy, there is but one one-rooted premolar. There are three species from the Wasatch and Bridger beds. The type is the *M. gracilis* Marsh (Fig. 2*b*), from the latter. It was a small animal, not exceeding a gray squirrel in dimensions. In Cynodontomys the premolar teeth are more reduced in size than in any of the allied genera, two of the three being one-rooted. The large ? incisor tooth has a correspondingly large development. The species was found by Mr. Wortman in the Wasatch beds of the Big Horn basin, Wyoming Terr.

FIG. 9.—*Mixodectes pungens* Cope, lower jaw right ramus, natural size. Fig. *a'*, from above. Original, from Vol. III Report U. S. Geolog. Survey Terrs.

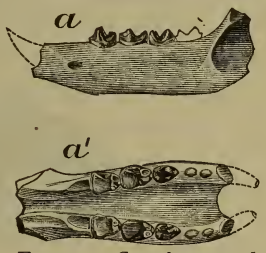


FIG. 10.—*Cynodontomys latidens* Cope, mandible, nat. size, from Wasatch beds of Wyoming. Fig. *a'*, from above. Original, from Report U. S. Geol. Surv. Terrs., Vol. III, F. V. Hayden in charge.

The most evident lemuroids yet found in America belong to the family of the Anaptomorphidæ. But one genus is certainly known to belong to it, Anaptomorphus Cope. The genus Indrodon[1] resembles it in dental formula excepting in the possession of three instead of two incisors. It embraces but one species, *I. malaris*, which was found by David Baldwin in the Puerco formation of New Mexico.

Anaptomorphus was founded on the lower jaw of a small species, *A. æmulus* Cope, which does not exceed that of a ground squirrel (Tamias) in size (Fig. 11). It agrees with a very few of the living lemurs (Indrisinæ) in the number of its teeth, but it differs from them all in having short erect incisor teeth as in the higher monkeys. The molar teeth known are a good deal like those of

[1] Proceedings American Philosophical Society, 1883, p. 318.

the true monkeys in character, being quadrituberculate. The last premolar is quite different, having a compressed, simple, cutting crown. The canine is quite small, and there is no diastema. The evidence furnished by this jaw was happily supplemented by the discovery, at a later day, of an almost entire cranium of a closely allied species in the Wasatch beds of Wyoming by Mr. J. L. Wortman. The species it indicated is rather larger than the *A. æmulus*, and I gave it the name of *A. homunculus* (Fig. 12).

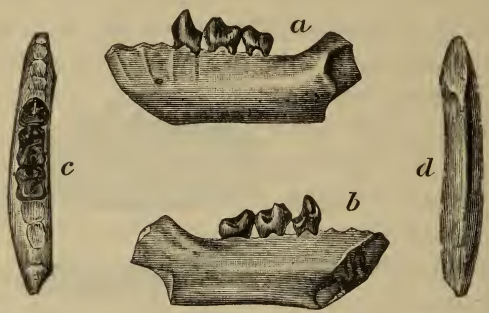


FIG. 11.—*Anaptomorphus æmulus* Cope, left ramus of mandible, twice natural size, linear; *b*, inner side; *c*, from above; *d*, from below. From Bridger bed of Wyoming. Original.

The characters of this genus now known warrant us in thinking it one of the most interesting of Eocene Mammalia. Two special characters confirm the reference to the Lemuroidea which its

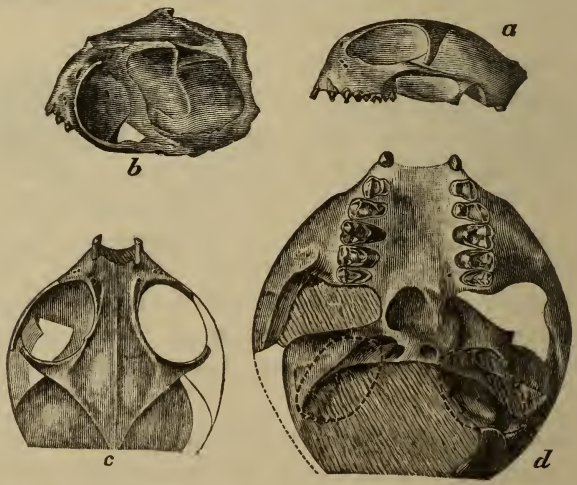


FIG. 12.—*Anaptomorphus homunculus*, skull, natural size except Fig. *d* which is one-half larger than nature, from the Wasatch beds of the Big Horn, Wyoming. Fig. *a*, right side of skull; *b*, oblique view of same showing outline of cerebral hemisphere, postorbital arch removed; *c*, same from above; *d*, the same from below, enlarged one-half, the dotted lines indicate the form of the otic bullæ. Original, from Report U. S. Geol. Survey Terrs.. III, F. V. Hayden in charge.

physiognomy suggests. These are the external position of the

lachrymal foramen and the unossified symphysis mandibuli. Among Lemuridæ its dental formula agrees only with the Indrisinæ, which have, like Anaptomorphus, two premolars in each jaw. But no known Lemuridæ possess interior lobes and cusps of all the premolars, so that in this respect, as in the number of its teeth, this genus resembles the higher monkeys, the Simiidæ and Hominidæ more than any existing member of the family. Of these two groups the resemblance is to the Hominidæ in the small size of the canine teeth. It has, however, a number of resemblances to Tarsius, which is perhaps its nearest ally among the lemurs, although that genus has three premolars. One of these points is the anterior extension of the otic bullæ, which is extensively overrun by the external pterygoid ala. A consequence of this arrangement is the external position of the foramen ovale, just as is seen in Tarsius. Another point is the probably inferior position of the foramen ovale. Though this part is broken away in the cranium of *Anaptomorphus homunculus*, the paroccipital process is preserved, and has the position seen in Tarsius, as distinguished from the Indrisinæ, Lemuridæ, Galaginæ, etc. In this it also resembles the true Quadrumana.

When we remember that the lower Quadrumana, the Hapalidæ and the Cebidæ, have three premolar teeth, the resemblance of Anaptomorphus to the higher members of that order is more evident. The brain and its hemispheres are not at all smaller than those of the Tarsius, or of the typical lemurs of the present period. This is important in view of the very small brains of the flesh-eating and ungulate Mammalia of the Eocene period so far as yet known. In conclusion, there is no doubt but that the genus Anaptomorphus is the most simian lemur yet discovered, and probably represents the family from which the anthropoid monkeys and men were derived. Its discovery is an important addition to our knowledge of the phylogeny of man.

The *Anaptomorphus homunculus* was nocturnal in its habits, and its food was probably like that of the smaller lemurs of Madagascar and the Malaysian islands. Its large orbits and large otic bullæ indicate great acuteness of the senses of sight and hearing. Its size is a little less than that of the *Tarsius spectrum*.

In Pelycodus we have a more decidedly insectivorous type of dentition in the lower jaw, although that of the upper jaw (Fig. 1) has a lemurine character. Enough of the poste-

rior foot is known to show that its structure is like that of Condylarthra, lemurs and the majority of the Insectivora (Figs. 14, 15, 16). The quadrituberculate superior molars (Fig. 1) forbid the reference of the genus to the Creodonta, and if all the ungues are like that represented in Figs. 11 *d*, it cannot be placed in either the Lemuroidea or Condylarthra, but is an insectivore more or less allied to the East Indian Tupæa. The ankle joint (Fig. 14) is flat, or without trochlea. The head of the astragalus is simple and convex, and is prolonged beyond the calcaneum, giving space for a rather long cuboideum. The lower end of the fibula is large (Fig. 15 *b*) and is extensively applied to the astragalus.

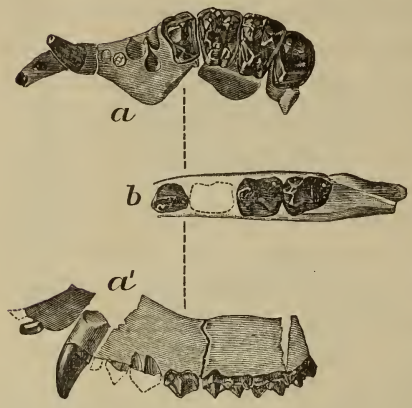


FIG. 13.—*Pelycodus tutus* Cope, portions of skull, from the Wasatch epoch of Wyoming, natural size. Fig. *a*, superior dentition from below; *a'*, the same, external view; *b*, inferior molars 4–6 and 7, from above. Original from Report U. S. Geol. Survey Terrs., III.

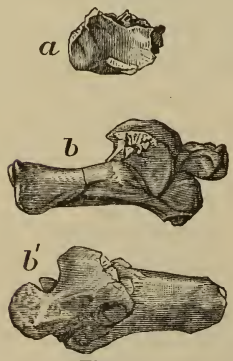


Fig. 14.

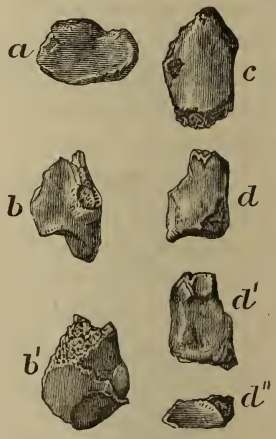


Fig. 15.

FIG. 14.—*Pelycodus jarrovii* Cope, ankle joint, nat. size. Fig. *a*, distal extremity of tibia; *b*, astragalus and calcaneum, external view; *b'*, do., internal superior view. From Wasatch bed New Mexico. Original, from Report U. S. Geol. Survey W. of 100th meridian.

FIG. 15.—*Pelycodus jarrovii* Cope, individual represented in Fig. 14, nat. size. Fig. *a*, head of radius; *b*, distal end of fibula; *c*, patella; *d*, entocuneïform, outer side, *d'*, inner side, *d''*, distal end. Original, from Report U. S. Geol. Survey W. of 100th mer., G. M. Wheeler.

The entocuneïform bone (Fig. 15 *d*) shows clearly that the hallux

was not opposable, a character which adds weight to those already mentioned which indicate that the true place of this genus is in the insectivorous order. The large patella (Fig. 15 *c*) shows that the genus is not marsupial. The head of the radius (Fig. 15 *a*) is an oval, agreeing in this with the orders mentioned, excepting the Lemuroidea, and showing that the supination of the manus could be only imperfectly or not at all performed.

But three species of Pelycodus are known, and these are confined to the Wasatch bed of New Mexico and Wyoming. Two species formerly referred here have been separated under the name Chriacus and placed in the Leptictidæ of the Creodont suborder.[1]

The family of the Arctocyonidæ includes more or less carnivorous animals with quadritubercular true molars above. The known genera, of which there are four, possess large canine teeth and quadritubercular inferior molars. The bones of Arctocyon have been described by Lemoine, so far as known, and they are like those of Creodonta, having a flat astragalus and an epicondylar foramen of the humerus. Their quadritubercular superior molars place them in the Insectivora as I have defined that suborder.[2] *Arctocyon primævus* Blv., is a celebrated fossil of the Suessonian beds of France. The single species of Hyodectes and Heteroborus are each from the Puerco beds of France. In America the family is represented by the genus Achænodon Cope, of which three species are known according to Osborn. The dentition is somewhat suilline in character, and Mr. Osborn has accordingly referred the genus to the suilline Artiodactyla. As none of the bones of the skeleton are known, the question remains unsettled. The anterior crest of the glenoid cavity grasps the condyle of the lower jaw as in a carnivorous animal,

FIG. 16.— *Pelycodus tutus* Cope, bones of digit found loose but together. Fig. *a*. metapodial; *b*, first, *c*, second, and *d*, ungual phalanges; *d'*. side, and *d''*, proximal end, nat. size. From Wasatch bed of New Mexico.

[1] See NATURALIST, 1884, pp. 348–352.

[2] Report U. S. Geol. Survey Terrs., III, p. 739.

but the character is also found in the peccary. The typical species, *A. insolens* Cope (Fig. 17), is as large as the largest bears. The *A. robustus* Osborn, is about the same size. A large part of the skull has been discovered. This displays a very high sagittal

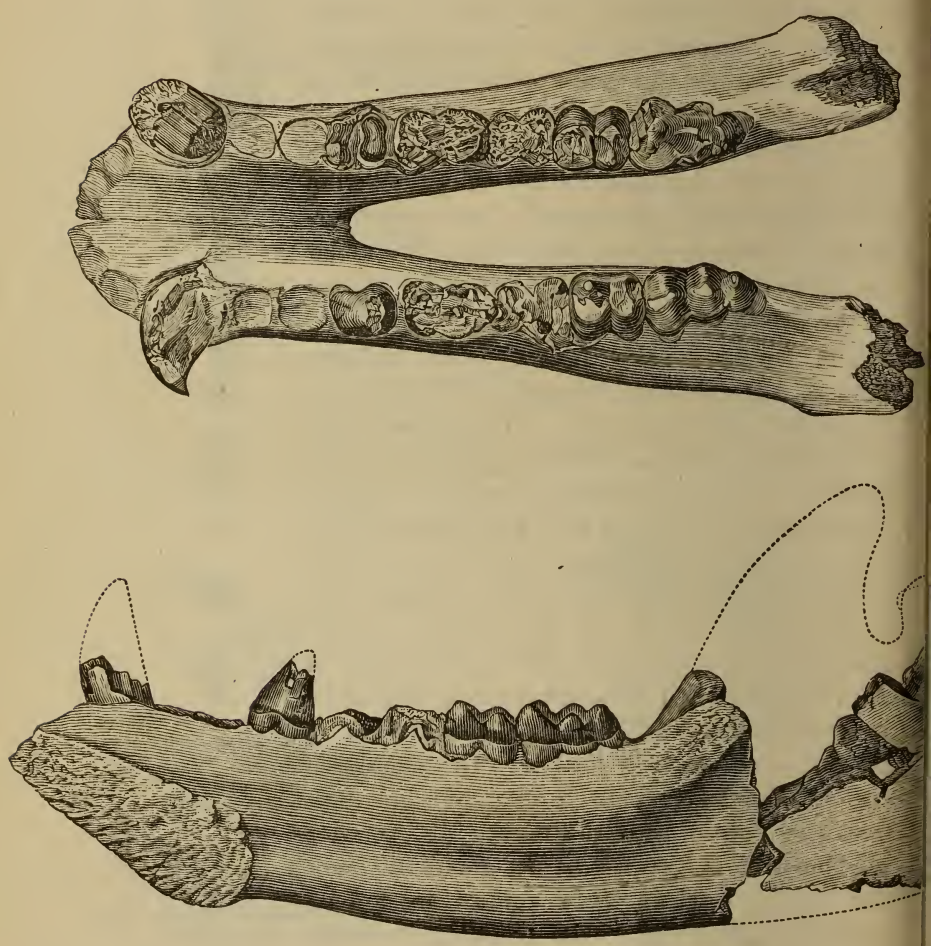


FIG. 17.—*Achænodon insolens* Cope, lower jaw, three-eighths nat. size, from above, and right ramus from inner side. From Bridger epoch of Wyoming. Original, from Vol. III Report U. S. Geol. Survey Terrs., F. V. Hayden in charge.

crest and a very small space for a brain. Its brain was probably of a low type, as has been shown to be the case in Arctocyon by Gervais. In that genus the hemispheres are smooth and very small, leaving the olfactory lobes and cerebellum entirely un-

covered. The resemblance to the brain of the opossum is well

FIG. 18.—*Achænodon robustus* Osborn, skull one-fourth nat. size, from the Bridger bed of the Washakie basin, Wyoming. Fig. *b*, maxillary bone with teeth from below. From Osborn, Bulletin No. 3, E. M. Mus. Princeton College.

marked. In *Achænodon robustus* the orbit is small, indicating comparatively imperfect powers of vision (Fig. 18).

PRINTED April 15, 1885.

13

THE

Tertiary Marsupialia.

BY E. D. COPE.

(*From the American Naturalist, July, 1884.*)

THE TERTIARY MARSUPIALIA.

BY E. D. COPE.

SINCE Cuvier discovered an opossum in the gypsum of Paris, the knowledge of the Marsupials of the Tertiary periods of Europe and North America has been gradually extended. In Europe they have been traced to the Middle Miocene, when they disappear from that continent. In North America we know them from Oligocene beds (White River), when they disappear, and are only known as yet thereafter as members of the existing fauna. Descending the scale we have them in the Laramie in America and Jurassic in America and Europe, and in the Trias in South Africa. Whether the Triassic Mammalia of the northern hemisphere belong to this order or not is uncertain. Under the head of Creodonta[1] I have discussed the marsupial resemblances of

[1] NATURALIST, March, April and May, 1884.

that division of Eocene mammals, showing that although their dentition is sometimes that of the carnivorous division of the marsupial order, they cannot be placed with them.

The extinct marsupials belong to three types, as distinguished by the form of their superior molar teeth. These are tritubercular, quadritubercular or multituberculate. To the first division belong the carnivorous types, or Sarcophaga of Owen; to the second the kangaroos and the wombats, to which Owen's name of Poëphaga may be applied.[1] The third division is entirely extinct, and is characterized by having at least three longitudinal series of tubercles in its superior molar teeth. To this suborder I apply the name of Multituberculata. The suborder Sarcophaga includes the opossums, and in North America the single extinct genus Peratherium [2]Aymard. This is also the genus which is found in the Oligocene and Miocene of France. It differs from Didelphys (the true opossum) in the non-inflection of the angle of the mandible. Otherwise the two genera are very similar, agreeing in the number (eight) of the inferior incisor teeth. Five species have been found in the White River beds of Colorado. The largest of these, *P. fugax* Cope (Fig. 1), had the skull as large as that of a mole (*Scalops aquaticus*). The smallest, *P. huntii* Cope, does not exceed a small shrew in dimensions.

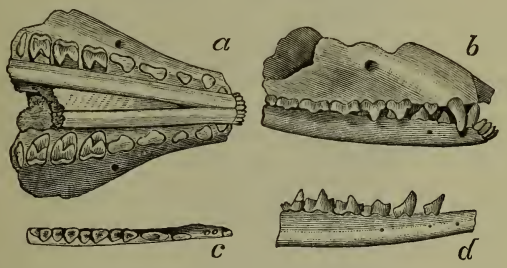


FIG. 1.—*Peratherium fugax* Cope, from the White River beds of Northeastern Colorado, twice natural size. Fig. *a*, anterior part of skull from below; *b*, do. right side; Fig. *c*, part of right mandibular ramus, with all the molars or their alveoli, from above; *d*, do., from the right side.

Of Poëphaga no extinct forms have been found in North America.

The Multituberculata include three families, which differ as follows:

Fourth superior premolar (at least) like true molars..... *Tritylodontidæ.*
Fourth premolars (and probably others) more simple than first true molars
Polymastodontidæ.
Fourth premolars (and often others) developed into flat cutting blades
Plagiaulacidæ.

[1] Owen places the Phascolomyidæ in a distinct suborder, but, as it appears to me, without sufficient reason. [2]Bulletin U. S. Geol. Survey Terrs, V, No. 1, p. 45.

In all three of these families the incisor teeth are in reduced numbers, and are constructed on the rodent type, with an external band of enamel. They thus approach the genus Phascolomys (wombat), one of the Poëphaga of the existing Australian fauna. The genus Tritylodon (Fig. 2), recently described by Owen, is from the South African Trias. It is a remarkably specialized form, considering its geological antiquity. Its formula above is, I. 2; Pm. 4; M. 3. The lower jaw is unknown. The median incisors are developed at the expense of the laterals, and are separated by a wide interspace. There is also a maxillary diastema. The molars and last premolars all support three rows of shortly conic tubercles (Fig. 7 *h*). The genus Stereognathus

FIG 2.—*Tritylodon longævus* Owen, anterior part of skull, natural size; from the Triassic beds of S. Africa. Fig. *a*, from below; *b*, from above. From Owen, Quart. Journ. Geol. Society, 1884, p. 146.

Charlesw., includes species from the English Oölite. The known molars have three longitudinal rows of crescentic tubercles (Fig. 7 *b*). The species are no larger than a small shrew, while the skull of *Tritylodon longævus* is as large as that of a gray fox. Information as to the structure of the skeleton of these remarkable forms has not yet been obtained.

There is but one genus of the Polymastodontidæ, the Polymastodon Cope. It is known from three species, all from the Puerco Eocene of New Mexico. The largest, *P. taoënsis* Cope, has bones equal in size to those of the large kangaroo, *Macropus major*. The jaw of the smallest species, *P. foliatus* (Fig. 5), is as large as that of *Hyrax capensis*; that of the third species, *P. fissidens*

Cope, is intermediate in dimensions, and the dentition has some well-marked peculiarities. The characters of the skeleton, so far as known, are derived from the *P. taoënsis* (Figs. 3 and 4).

The angle of the lower jaw is inflected, and the dental foramen is at the anterior apex of a large fossa, as in most marsupials. There are but two true molars in each jaw, and a single simple premolar, below. The condyle of the humerus presents characters shared by Meniscoëssus of the Laramie, which are found in lizards. There is a strong and thick intertrochlear ridge in front, which is so swollen at one side of the middle line as to resemble the condyle

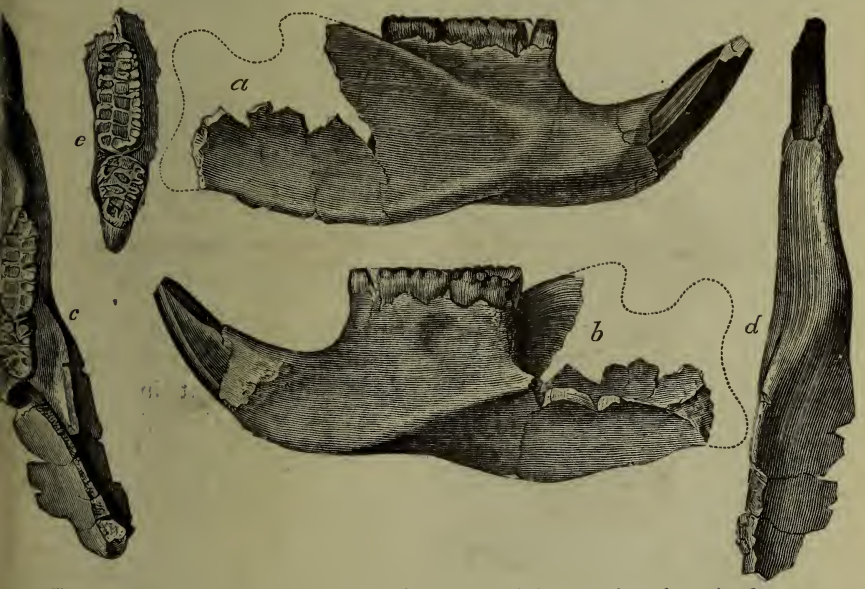


FIG.—3. *Pelymastodon taoënsis* Cope, jaws, two thirds nat. size; from the Lower Puerco beds of New Mexico. Fig. *a*, right mandibular ramus right side; *b*, do., internal side; *c*, do., from above; *d*, from below. Original, from Report U. S. Geol. Survey Terrs., F. V. Hayden in charge, Vol. III.

of a femur. The trochlea for the coronoid process of the ulna, on the posterior side, is narrowed so as to suggest a rotular groove (Fig 4*b'*). The humeral cotylus of the ulna is adapted to this condyle by a flare on each side (Fig. 4*c*). The astragalus is without trochlea, as in most Puerco Mammalia, and the trochlear portion is gently convex anteroposteriorly. The head is much narrowed, and has a narrow navicular face which is convex in only one, the vertical direction. On its outer side it bears a large flat facet for the cuboid bone (Fig. 4*d'*). This form is much like that of the kangaroos. It shows that the peculiar structure of the posterior foot of the Macropodidæ already existed at this early day, though

perhaps in not quite so specialized a condition as at the present time. The form of the astragalus shows that the internal digits

FIG. 4.—*Polymastodon taoënsis* Cope; parts of individual represented in Fig. 3, two-thirds nat. size. Fig. 4*a*, caudal vertebra, front; *a'*, do., left side; *b*, humerus, distal portion, front; *b'*, posterior side. Fig. 4*c*, ulna, proximal part, front side; *c'*, from above. Fig. 4*d*, astragalus, from above; *d''*, do., from external side. Original, from Report U. S. G. Survey Terrs., F. V. Hayden in charge, Vol. III.

are of very reduced size, the first probably wanting, in Polymastodon, and that the external digits were large and constituted the principal agent in progression. That the animal had a large tail is proven by the few caudal vertebræ preserved (Fig. 4*aa'*).

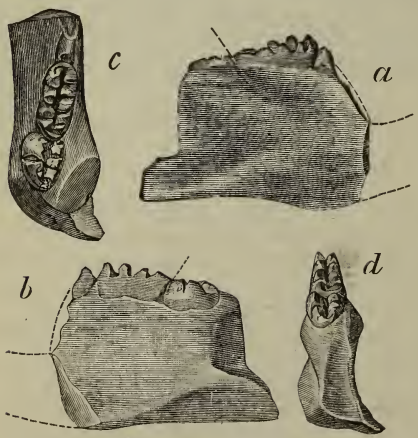


FIG. 5.—*Polymastodon foliatus* Cope; part of right mandibular ramus, natural size, Fig. 5*a*, right side; *b*, left do.; *c*, from above; *d*, posterior view, showing masseteric and dental fossæ. From the Lower Puerco of New Mexico. Original, from the Report of the U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III.

The inferior molars have but two rows of tubercles, and the penultimate is much larger than the last one. The former tooth looks a good deal like a reduced last inferior molar of some species of Mastodon. The family was of herbivorous habits, and is probably the ancestral type of the kangaroos. The discovery of this remarkable genus in our Lower Eocene beds marks an important advance in the knowledge of the origin

of one of the most interesting of living forms. On the other hand, the Polymastodontidæ may well have derived their origin from the Tritylodontidæ, which were also of herbivorous or granivorous habits. The family of the Plagiaulacidæ[1] is one of the most peculiar among those of the Mammalia, whether we consider its structure or its relations to geological time. Commencing in the Jurassic period, it persisted through the Cretaceous to the Eocene. It then disappeared from view to remind us once more of its existence by its probable descendant, the extraordinary pouched lion of the Pliocene period of Australia, *Thylacoleo carnifex* Owen (Fig. 9). The family exhibits the usual successional relation of its component genera. In this respect it repeats what I have already pointed out as a law of succession in placental Mammalia,[2] a reduction in the number of premolar teeth. The following table exhibits these relations:

I. Tubercles of superior molar crescentic.

Fourth premolar serrate, not ridged ..... *Meniscoëssus.*

II. Tubercles of molars subconic.

a. Four compressed premolars below.

Premolars serrate, not ridged ..... *Ctenacodon.*

Premolars ridged and serrate ..... *Plioprion.*[3]

aa. Three compressed premolars.

Premolars ridged ..... *Plagiaulax.*

aaa. Two premolars.

Fourth premolar ridged ..... *Ptilodus.*

aaaa. One premolar.[4]

Fourth premolar ridged ..... *Neoplagiaulax.*

Fourth premolar smooth ..... *Liotomus.*[5]

Of these seven genera but nine species are thus far known. Ptilodus and Ctenacodon have two species each; and each of the others but one. Ctenacodon, Plagiaulax and Plioprion are Jurassic; Meniscoëssus is Cretaceous, and the remaining three genera are Eocene Tertiary. The American genera are Ctenacodon Marsh (Fig. 7 *g*), Meniscoëssus Cope, and Ptilodus Cope. The first named is the most generalized of the family. The *Meniscoëssus conquistus* Cope, has the distinction of being the only known mammal of the Cretaceous period.

[1] This family is the equivalent of Marsh's "order" Allotheria.

[2] Bulletin U. S. Geol. Survey Terrs., VI, p. 168.

[3] Gen. nov., type *Plagiaulax minor* Falconer.

[4] Number unknown in Liotomus.

[5] Gen. nov., type *Neoplagiaulax marshii* Lemoine.

The genus first discovered was the Plagiaulax of Owen, of which the typical species was found in the Purbeck bed of the Isle of Wight, England. It was made the subject of a memoir by Falconer. Ctenacodon was next discovered in the Jurassic of Wyoming by Marsh in 1879. In 1880 Dr. Lemoine discovered the first Tertiary representative of the family, and in 1882 named it *Neoplagiaulax eocænus* (Fig. 6). In November, 1881, I described the first American Tertiary form, which was discovered in the Puerco beds of New Mexico, under the name of *Ptilodus*

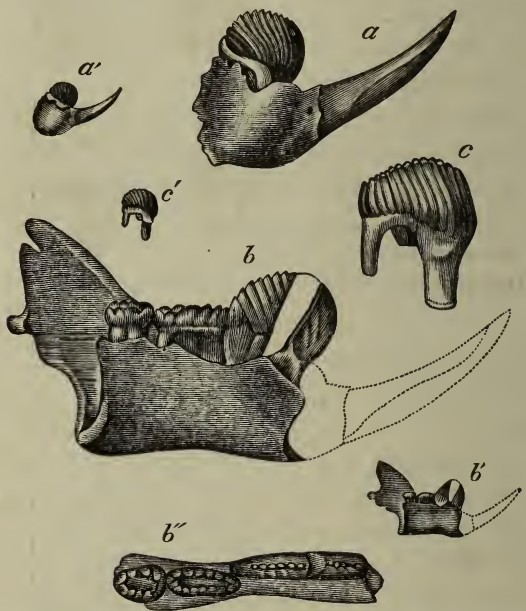


FIG. 6.—*Neoplagiaulax eocænus* Lemoine, from the Cernaysian beds of Reims, France; mandibular rami and teeth of three individuals which are represented by the letters *a*, *b* and *c*. Figs. *a*. *b*, and *c*, much enlarged. Figs. *a′*, *b′* and *c′*, natural size. Fig. *b‴*, from above. From Lemoine, Bulletin de Soc. Geol. de France, 1882, p. 249.

mediævus (Fig. 8). Its presence in that formation, together with various other associated types, proved the near homotaxy of the beds explored by Dr. Lemoine near Reims with those of New Mexico.[1]

Up to this time the great Cretaceous period had remained a blank in the history of Mammalian life. European palæontologists had examined the fresh-water beds of this period for mammalian remains without success. Among them, the gifted Kowalev-

[1] See the NATURALIST, 1883, p. 870.

sky, too soon lost to science, spent much time in the south of France among the formations which most nearly represent the American Laramie formation, but found no Mammalia. It remained for Mr. Wortman to crown a series of successful expeditions by the discovery of the *Meniscoëssus conquistus* in the Laramie formation of Dakota, its loose teeth being found mixed with the teeth of dinosaurs and scales of gar-fishes. The characters of the molar teeth are highly appropriate to the geological age of the genus, the superior molar resemblinhg bot that of the Jurassic Stereognathus and the Eocene Polymastodon.

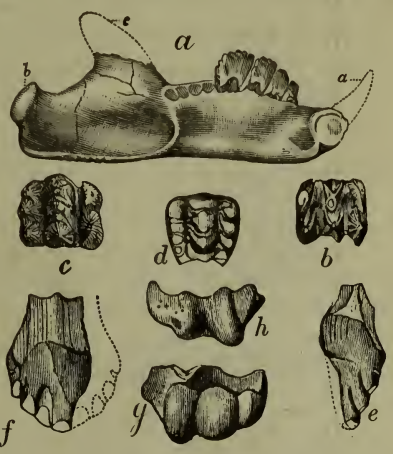


FIG. 7.—Fig. *a*, *Ctenacodon serratus* Marsh, $\frac{3}{4}$ nat. size, from Marsh. Fig. *b*, molar of *Stereognathus oöliticus*, $\frac{3}{1}$, from Owen. Fig *c*, right fourth upper molar of *Tritylodon longæ*, *vis*, from Owen, $\frac{3}{1}$. Figs. *d–f*, *Meniscoëssus conquistus* Cope, $\frac{3}{2}$ nat. size. Fig. *d*, superior molar; Figs. *e–f*, superior fourth premolar[1]; *g*, humeral condyles of a smaller species with jaw, found with the *Meniscoëssus*.

I have shown that the cutting tooth of the lower jaw in the genera with but one such tooth, as Ptilodus and Thylacoleo, is the fourth premolar;[2] while the similar tooth in the existing kangaroo-rats, with which it has been compared, is a third premolar. In the living genera the fourth premolar resembles a true molar. It is necessary to remember this fact in the attempt to ascertain the phylogeny of the Multituberculata. This is not an entirely easy task, owing to the questions which arise as to the origin of the cutting premolars themselves. In general it is true of Mammalia that simple premolars precede the complex in time; but an exception to this rule is to be seen in the tritubercular superior sectorial tooth of some Creodonta and Carnivora. Whether the premolars of this family are primitive or derivative is not as yet known. If they be primitive they may be direct modifications of the serrate teeth of the herbivorous Dinosauria or Theromorpha. The complex character of the premolars in the older Tritylodon suggests the possibility of the other alternative. The general history of the Plagiaulacidæ con-

[1] This tooth may possibly belong to a Saurian.
[2] NATURALIST, 1882, p. 521.

firms the theory of derivation from complex premolars, and we observe in the later form, Thylacoleo, a simplification of the true molars also. The molariform fourth premolars in the existing Macropodidæ confirm this view. In order to connect these latter with the ancestral form of the Plagiaulacidæ, on a former occasion, I posited a theoretical form which should combine three of the cutting premolars of the extinct family with the molariform fourth premolar of the Macropodidæ. This I named Tritomodon.[1] The discovery of Tritylodon has added confirmation to this view, at least as regards the prior existence of the molariform premolars. The Polymastodontidæ were probably derived from the Tritylodontidæ by the usual process of reduction of number of teeth and specialization of those that remain. Thylacoleo[2] must be regarded as the type of a family distinct from the Plagiaulacidæ, since it has but one true molar tooth in the upper jaw. The composition of that tooth is unknown, so that it is not certain whether the family Thylacoleontidæ must be placed in the Multituberculata or Sarcophaga. That it is a direct descendant of the Plagiaulacidæ I think there is no doubt. The following phylogenetic scheme is similar to one I published in the NATURALIST, 1882, p. 521, with some addition, and the removal of Polymastodon (Catopsalis) from the Plagiaulacidæ:

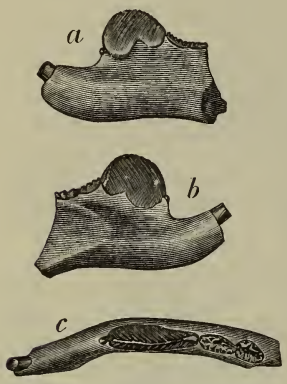
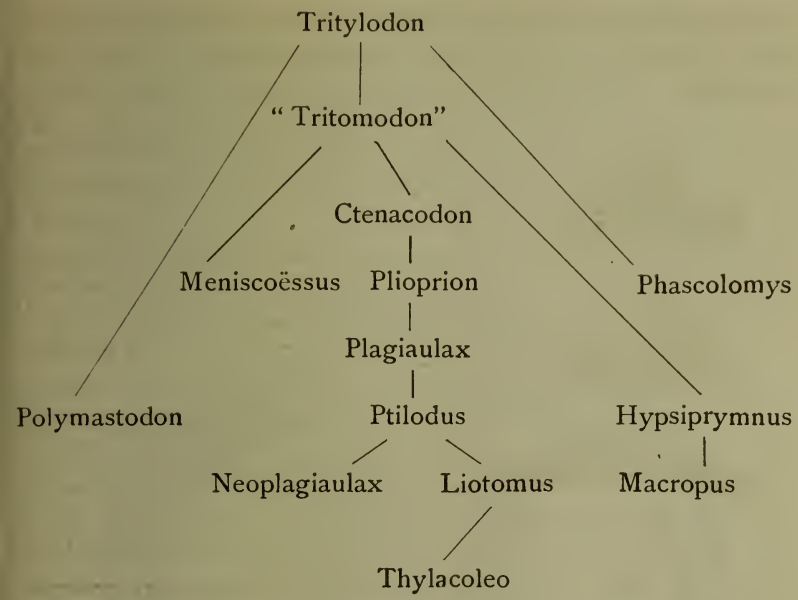


FIG. 8. — *Ptilodus mediævus* Cope, left mandibular ramus, nat. size; from the Upper Puerco beds of New Mexico. Fig. *a*, external side; *b*, internal do.; *c*, superior view, $\frac{3}{2}$ nat. size. Original, from Report U. S. Geol. Survey Terrs., III, F. V. Hayden in charge.

[1] NATURALIST, 1882, p. 521.

[2] Owen, Quar. Journ. Geol. Society, London, 1883.



It appears from the preceding considerations that the dentition of the implacental Mammalia has had a history independent of that of the placental series so far as regards the herbivorous types at least. I have shown that the primitive types of the placental series were tritubercular, and then quadritubercular, and then crested. In the herbivorous marsupials, on the contrary, we commence with multitubercular forms, and it is yet an open question whether these have had a quadri- and tritubercular ancestry or not.

The Plagiaulacidæ of the Jurassic period are of very small size, none of them exceeding in dimensions the house mouse. The same is true of the species of the Eocene period hitherto found in Europe. The American species are larger, the *Ptilodus mediævus* equaling probably the Norway rat (Fig. 8), while the *P. trovessartianus* is one-third smaller. The *Meniscoëssus conquistus* is still larger, equaling about the *Polymastodon foliatus* (Fig. 7). The arrangement of the crests of the fourth premolar in the species of Plagiaulacidæ differs as follows: In Plagiaulax, Plioprion and Neoplagiaulax this tooth is grooved. In Ptilodus the grooves have become so wide (Fig. 8) that the wide intervening ribs have become narrow keels. In Meniscoëssus there are no keels, but the margin of the crown is serrate (Fig. 7 *a c*).

The *Ptilodus mediævus* further differs from the *Neoplagiaulax eocænus* in the more rodent-like character of its incisor teeth. In the latter species these teeth resemble more those of the kangaroos in their anterior direction. The diastema is longer in Ptilodus, thus increasing the rodent resemblance. The fourth premolar is strongly serrate in the Neoplagiaulax, resembling in this also the Mesozoic types.

The discussion between Professor Owen on the one side, and

FIG. 9.—*Thylacoleo carnifex* Owen; skull from below, one half nat. size; from the Pliocene beds of Australia. From restoration by Professor Owen in *Geological Magazine*, 1883, p. 289.

Messrs. Falconer, Krefft and Flower on the other, as to the nature of the food of Thylacoleo, is known to palæontologists. From the form of the teeth alone, Professor Owen inferred the carnivorous nature of the food of this genus, while his opponents inferred a herbivorous diet from the resemblance between the dentition and that of the herbivorous Hypsiprymnus. I have pointed out (*l. c.*) that the comparison of Thylacoleo with Hypsiprimnus

is weakened by two considerations: First, the cutting teeth in the two genera are not homologous; second, the grinding series of molars, complete in Hypsiprymnus, is almost wanting in Thylacoleo. It evidently does not follow that because Hypsiprymnus is herbivorous Thylacoleo is so also. Professor Flower refers to the reduction of the molars in Thylacoleo as slightly complicating the problem, and concludes that the food of that animal may have been fruit or juicy roots, or even meat. It is difficult to imagine what kind of vegetable food could have been appropriated by such a dentition as that of Ptilodus and Thylacoleo. The sharp, thin, serrate or smooth edges are adapted for making cuts and dividing food into pieces. That these pieces were swallowed whole is indicated by the small size and weak structure of the molar teeth, which are not adapted for crushing or grinding anything but very small and soft bodies. It is not necessary to suppose that the dentition was used on the same kind of food in the large and the small species. In *Ptilodus mediævus* the diet may have consisted of small eggs which were picked up by the incisors and cut by the fourth premolars. In *Thylacoleo carnifex* it might have been larger eggs, as those of the crocodiles, or even the weaker living animals. The objection to the supposition that the food consisted of vegetables, is found in the necessity of swallowing the pieces without mastication. In case it should have been of a vegetable character the peculiar premolar teeth would cut off pieces of fruits and other soft parts as suggested by Professor Flower, but that these genera could have been herbivorous in the manner of the existing kangaroos, with their full series of molars in both jaws, is clearly an inadmissible supposition.

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(14)

THE BATRACHIA

OF THE

PERMIAN PERIOD OF NORTH AMERICA.

By PROF. E. D. COPE.

From the American Naturalist, January, 1884.

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THE BATRACHIA OF THE PERMIAN PERIOD OF NORTH AMERICA.

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THE class Batrachia holds an important position in the history of the Vertebrata, as the first member of that kingdom which occupied the land on the advent of the conditions suitable for air-breathing types. It thus stands in ancestral relation to the lines of the Sauropsida and Mammalia, and as the immediate descendant of the fishes.

There are several orders of Batrachia, and they display remarkable diversities of skeletal structure. For the better understanding of these, I give the following table of their principal definitions :[1]

I. Supraoccipital, intercalary and supratemporal bones present. Propodial bones distinct.

Vertebral centra, including atlas, segmented, one set of segments together supporting one arch ..... *Rhachitomi.*

Vertebræ segmented, the superior and inferior segments each complete, forming two centra to each arch. ..... *Embolomeri*

Vertebral centra, including atlas, not segmented; one to each arch.... *Stegocephali.*

II. Supraoccipital and supratemporal bones wanting. Frontal and propodial bones distinct.

a An os intercalare.

A palatine arch and separate caudal vertebræ..... *Proteida.*

aa No os intercalare.

A maxillary arch; palatine arch imperfect; nasals, premaxillaries and caudal vertebræ distinct ..... *Urodela.*

Maxillary and palatine arches distinct; nasals and premaxillaries united *Gymnophiona.*

No maxillary or palatine arches; nasals and premaxillary, also caudal vertebræ, distinct ..... *Trachystomata.*

III. Supraoccipital, intercalare and supratemporal bones wanting. Frontals and parietals connate; propodial bones and caudal vertebræ confluent.

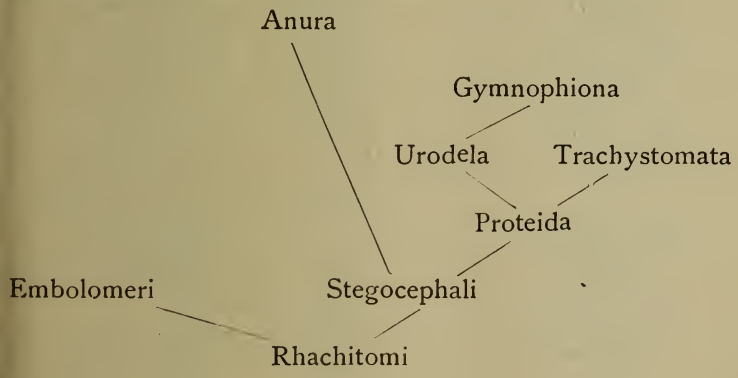
Premaxillaries distinct from nasals; no palatine arch; astragalus and calcaneum elongate, forming a distinct segment of the limb..... *Anura.*

The animals of the division I are all extinct. Division II includes the salamanders and their allies, with the worm-like Cœcilians (Gymnophiona); while the third division embraces the frogs, toads, etc.

[1] This is partly derived from the table which I have given in Vol. II Palæontology of the Geological Survey of Ohio, 1874, p. 352. See also Proceedings Philadelphia Academy, 1868, p. 211.

The characters displayed by the three divisions in question, indicate their relationships to be as follows: The orders of division 1 present in their cranial structure a greater resemblance to the limb-finned or crossopterygian fishes, than do either of the others. The third division is the most divergent from that type, and is in various respects the most specialized. This specialization consists not only in a departure from the primitive Batrachia, but also from all other forms of Vertebrata. Its specialization is seen in the loss and coössification of various parts of the skeleton. The Urodela display characters intermediate between the extremes of the class. Near them the Trachystomata (Sirenidæ) are inferior by loss of parts of the skull, and of the pelvic arch, the result, probably, of a process of degeneration. The same is probably true of the Proteida, which have lost the maxillary arch of the Stegocephali, but retain their os intercalare.[1]

As regards the extinct orders, the primitive type is evidently the Rhachitomi, whose vertebral column displays an arrest of characters which are transitional in the higher Vertebrata. From this group the orders Embolomeri and Stegocephali have evidently been derived. We may then present the following genealogical table of the class Batrachia:



As regards the connection of the class, as a whole, with other classes of Vertebrata, it is very probable that the extinct orders, as the Rhachitomi, were derived from some extinct form of Dipnoan fishes more or less related to the group of which the genus Ceratodus is a representative. In this type we have a persistent chorda dorsalis; fins which present the type from which ambulatory

[1] Of Cuvier; Epiotic of Huxley, according to Vrolik.

limbs were derived; a pelvis; and a cranium nearer that of the batrachians than most other fishes present. The Crossopterygia are a little on one side of the parental stem, since they have no pelvis, and their limbs begin to show a beginning of that reduction and specialization, which is carried to such an extent in the Actinopteri, or typical fishes.

The Batrachia are supposed by Professor Huxley to have given origin to the Mammalia. There are many reasons to sustain this view, nevertheless no progress has yet been made by palæontological research in filling up the great interval which separates the Permian Batrachia from the Mesozoic Mammalia. It is also true that the limb bones of the Permian Reptilian order of the Theromorpha more nearly resemble those of the lowest Mammalia, the Monotremata, than do those of any other known forms.

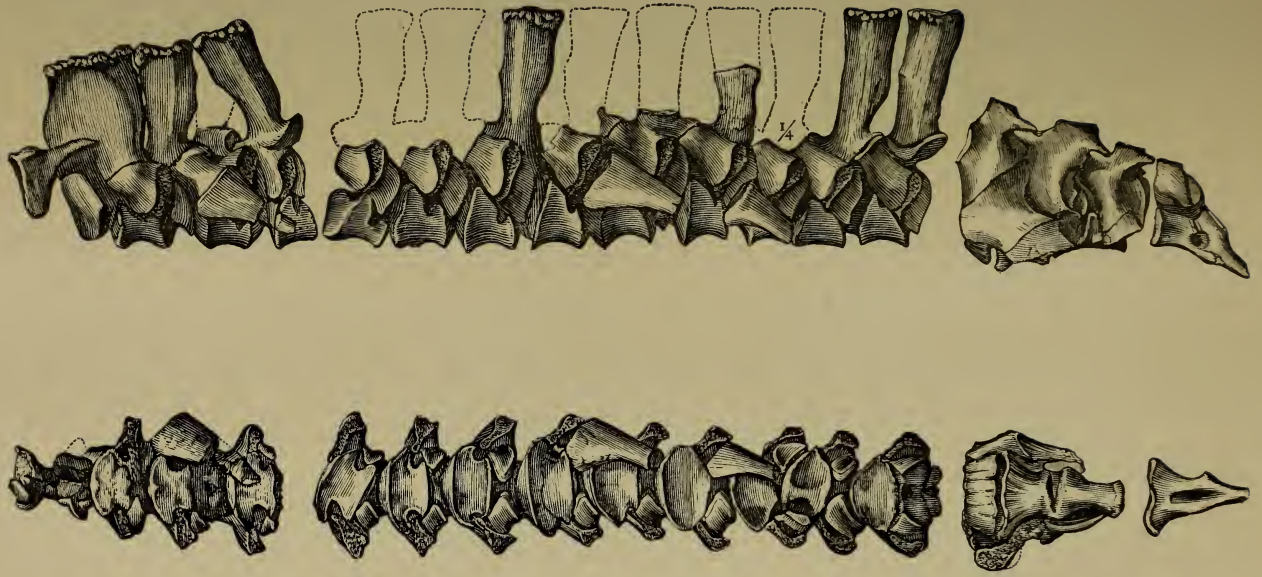
The Rachitomi.

I proposed this name[1] for a division of the Batrachia which predominated during the Permian period in both the old and new worlds. As stated above in the differential table, it is characterized by the primitive condition of its vertebral column. The cartilaginous chorda dorsalis was present in life, and the vertebral bodies are represented by ossifications of its sheath. In the Trimerorhachidæ this ossification is superficial or cortical, while in the Eryopidæ it penetrated more deeply into the chorda. The segments of the centrum are three in number, an inferior one or intercentrum, and a superior lateral one on each side, the pleurocentrum, as it is called by Gaudry. The lateral pieces support the neural arch, and on this account I have called them the centrum proper, as distinguished from the intercentrum. The neural arch is unbroken, and displays articular processes (zygapophyses) of usual form, and in some genera a large neural spine.

The shoulder-girdle of these animals is remarkable for the small size of the coracoid element, resembling in this respect the salamanders, and approaching the mammals. There is probably a clavicle, as has been observed by Gaudry in Actinodon. He also finds the three thoracic shields of the Stegocephali (episterna and entosternum). I have such bones associated with the American forms, but have not yet determined their species. The humerus has no head, but a band-like articular surface instead.

[1] American Naturalist, 1882, p. 333.

PLATE II.



ERYOPS MEGACEPHALUS Cope. ¼

Its condyles, when present, are, on the other hand, well developed, and resemble those of salamanders, and of certain Mesozoic and lowest Tertiary mammals, as Meniscoëssus of the Laramie, and Catopsalis of the Puerco. The terminal phalanges were not converted into claws, but were flat and obtuse, as in existing Batrachia.

The pelvic arch is intermediate between those of the Anura and salamanders, and resembled closely that of the Pelycosaurian division of the Theromorphous reptiles of the same age. The pubis and ischium are solidly united, without the intervention of an obturator foramen, and those of opposite sides form a boat-shaped body. This is suspended from the sacrum by a vertical ilium, which rises from near the middle of each side. Its proportions are about as in the salamanders. The femur has no head proper, and the distal condyles are better distinguished than in any other Batrachia and than in most Reptilia.

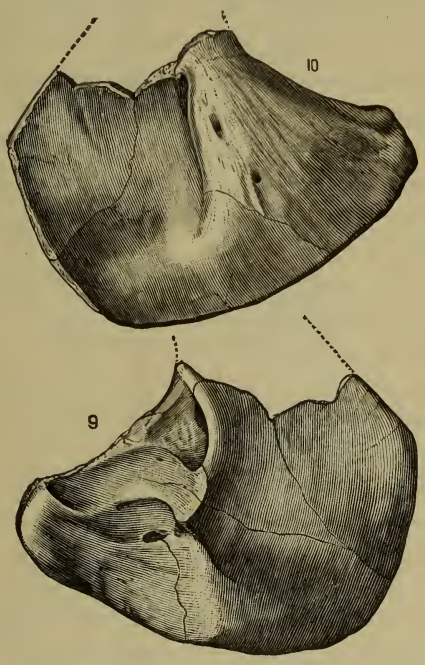


FIG. 1.—*Eryops megacephalus* Cope. Inferior part of scapular arch of a different individual from that represented in Pl. II; four-fifteenths nat. size. Upper figure from front; lower, posterior view.

The species of the Rachitomi are rather salamander-like in proportions, with relatively short legs and long tail, except in Eryops, where the latter was probably represented by a stump (see Plate II). They had relatively large heads with wide gape, as in the frogs. None of the known species can be supposed to have had powers of leaping as in those modern animals.

None of the known species had a formidable dentition, and in all of them the dentine is simply inflected, so that the section of a tooth presents a mass of closely-packed radii.

The two families of this order are well distinguished by the

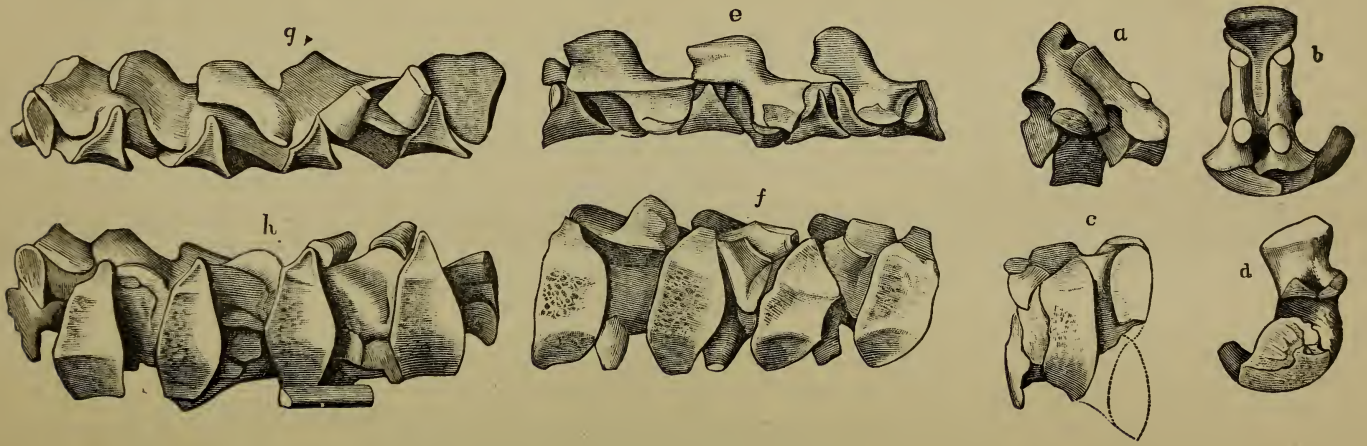
form of the basioccipital bone. In the Trimerorhachidæ its condyle is simple and concave, somewhat as in some fishes. The Eryopidæ have the two condyles characteristic of Batrachia generally. This difference might be esteemed as of greater than family significance, but it is less considerable than at first sight appears. The single cotylus-like basioccipital bone of the Trimerorhachidæ is notched above, sometimes deeply, to receive the apex of the notochord. A corresponding notch on the inferior edge would, if present, divide the articulation into two surfaces, which would greatly resemble the condyles of Eryops. The latter are flat and look partly towards each other, and are evidently separated originally by the *fissura notochordæ*.

To the Trimerorhachidæ I have referred, with certainty, only the genus Trimerorhachis. I have been unable to learn the structure of the vertebræ in the European genus Archegosaurus. According to some authors they are simple, as in the Stegocephali. Specimens of this kind, of the size of the *Archegosaurus decheni*, are found in the locality where the latter occurs, *i. e.*, Saarbrücken in Alsace; while rachitomous vertebræ from the same locality are of larger size, and resemble those of Eryops (Mus. Princeton, N. J.).

I have called attention to the structure of the vertebral column of the Rachitomi from a mechanical standpoint.[1] The notochord persists, the osseous elements about it in the sheath or skin, in the form of regular concave segments much like such segments as are cut from the skin of an orange, *i. e.*, parts of spheres, having greater or less thickness according to the group or species. Now the point of divergence of these segments is on the side of the column, the upper segments rising, and the lower segments expanding downwards. To the upper segments are attached the arches and their articulation, and the lower segments are like the segments of a sphere. If you take a flexible cylinder, covered with a more or less resistant skin or sheath, and bend that cylinder sidewise, you will of course find that the folds of the surface will take place along the line of the shortest curve, which is on the side; and, as a matter of fact, you will have breaks of very much the character of the sutures of these vertebral segments. It may not be so symmetrical as in the actual animal, for organic growth is symmetrical so far as not interfered with; for, when we have two

[1] *Science*, 1883, p. 276.

PLATE IV.



TRIMERORHACHIS INSIGNIS Cope. $\frac{1}{1}$

forces, the one of growth and the other of change or interruption, and they contend, we still have in the organic being a quite symmetrical result. In the cylinder bending in this way, of course the shortest line of curve is at the center of the side of the cylinder, and the longest curve is at the summit and base, and the shortest curve will be the point of fracture. And I presume it has happened in the case of the construction of the segments of the sheath of the vertebral column that the lateral motion of the animal swimming has been the actual cause of the disposition of the osseous material in this form.

A very good illustration of the effect of bending of a more or less flexible cylinder may be seen in the folds on the inner concave side of one's coat sleeve. In the accompanying figure the folds in the cloth represent the lines of flexure, or what would be

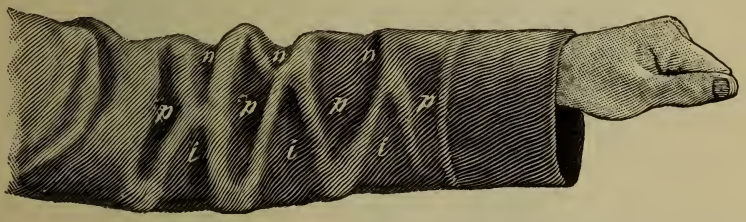


FIG. 2.—Sleeve of a coat, showing folds produced by lateral flexure, which leave interspaces similar to the segments of a rachitomous vertebra. Thus *i* represents intercentrum, *p*, pleurocentrum, and *n*, neurapophysis.

in a seat of ossific deposit, of interruption; while the interspaces represent the segments bounded by such lines. The correspondence with the segments of the vertebræ of the Rhachitomi is remarkable. At the base we have the wide lenticular intercentrum (viewed partly from below in the cut); between their lateral apices we have the pleurocentra, and above, another segment, which in the vertebra is the base of the neural arch.

The view that the segmentation of the vertebral column is the result of lateral alternating strains, was proposed by Herbert Spencer (Principles of Biology, II, p. 195). The present researches confirm this hypothesis in general. Mr. Spencer did not, however, specify the kind of segmentation to be expected from this process, and leaves it to be inferred that the segments will be cylinders of greater or less length. Thus he says (p. 205) " in a vertebral column of which the axis is beginning to ossify, the centrums consist of bony rings inclosing a still continuous rod of cartilage." And it is true that this is the primitive form in

embryology, but whether true in any instance in palæontological history yet remains to be ascertained.

TRIMERORHACHIS Cope.

This genus presents the most imperfect vertebræ known in the order. It differs from all others, including Archegosaurus, in the lack of a distinct neural spine. Its humeri do not display condyles, but had cartilaginous articular surfaces. The teeth are rather small

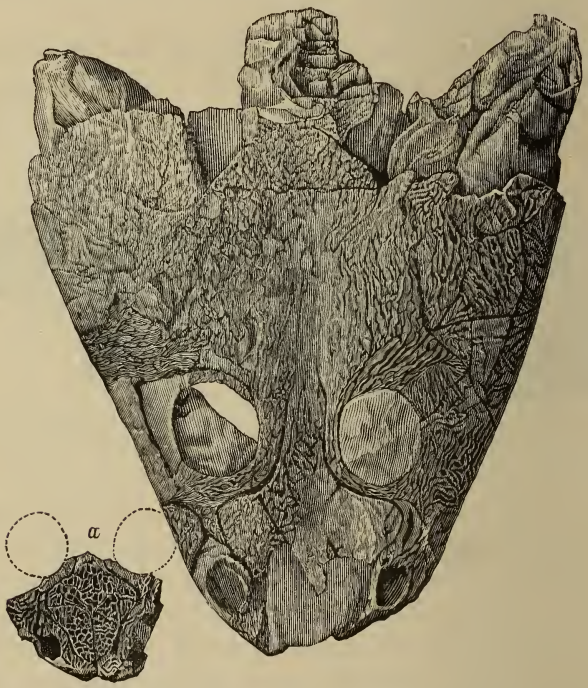


FIG. 3.—*Trimerorhachis insignis*, skull from above; one-half natural size. Smaller figure; muzzle showing sculpture and nares.

and of equal size, except a large one or two inside the external series near the anterior part of the mouth.

Two species are known, the *T. insignis* Cope, and *T. bilobatus* Cope, both from the Permian beds of Texas. Both were probably of slender proportions, and had short weak limbs.[1] The head of the *T. insignis* is wide, flat and rounded, and its superior surface is strongly wrinkled. The lyriform mucous groove does

[1] This proportion is not certainly known.

not extend behind the orbits. This was a very abundant species

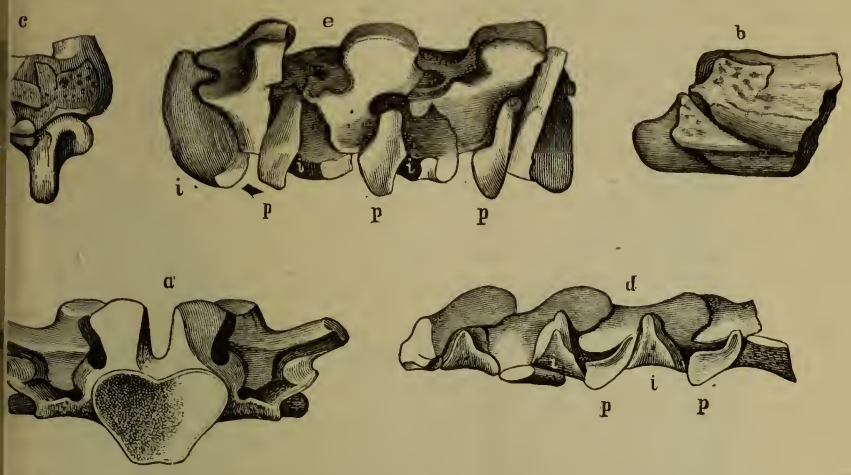


FIG. 4.—*Trimerorachis insignis* Cope; parts of skeleton, natural size. Fig. *a* basi-occipital, exoccipital and periotic bones, posterior view; *b*, angle of mandible, external view; *c*, the same, posterior view; *d*, part of vertebral column depressed by pressure, showing the intercentra (*i*) and the pleurocentra (*p*); *e*, a part of the vertebral column, oblique view, showing double neural arches and zygapophyses.

during the Permian period in Texas, and probably possessed aquatic habits.

ERYOPS Cope.

This genus is the best-known American representative of the Eryopidæ. This family includes also Acheloma, Anisodexis, and probably Zatrachys in America, and Actinodon in Europe. The last-named genus occurs in the Permian beds near Autun, in Central France, and has been well elucidated by the labors of Professor Gaudry of the Jardin des Plantes.

In Eryops the teeth are arranged much as in Trimerorhachis, in external series of nearly uniform size, with some large ones in the anterior parts of both jaws, a little within the external rows. As in that genus, the supra-temporal does not display a free external margin, as it does in Cricotus, and there is no angular process of the mandible. There is, on the other hand, no lyra. The intercentra and pleurocentra are much more robust than in Trimerorhachis. The neural spines of the vertebræ are large, and have expanded summits. The caudal vertebræ appear to have been very few, and to have been confluent into a short conical coccyx. The inferior elements of the pelvis are remarkably

heavy, the pubis being thickened in front, and truncated with a flat V-shaped face with reverted lip.

Three species of this genus are known. The most abundant in the Permian of Texas is the *E. megacephalus* Cope (Figs. 1 and 5–6). This is the largest American batrachian, the skull measuring a foot wide by eighteen inches long. It was very abun-

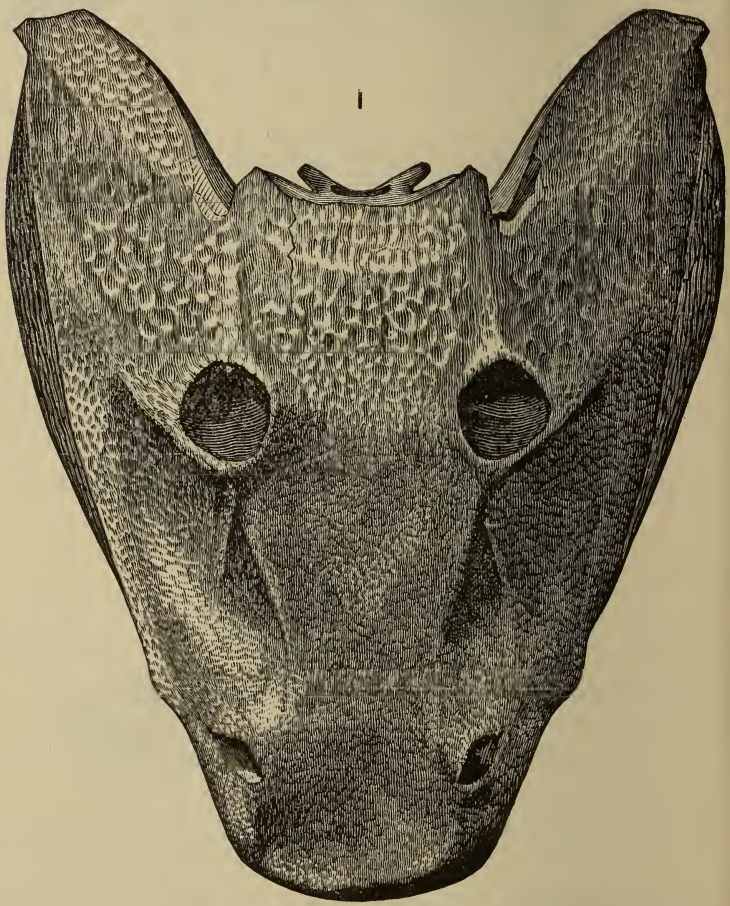
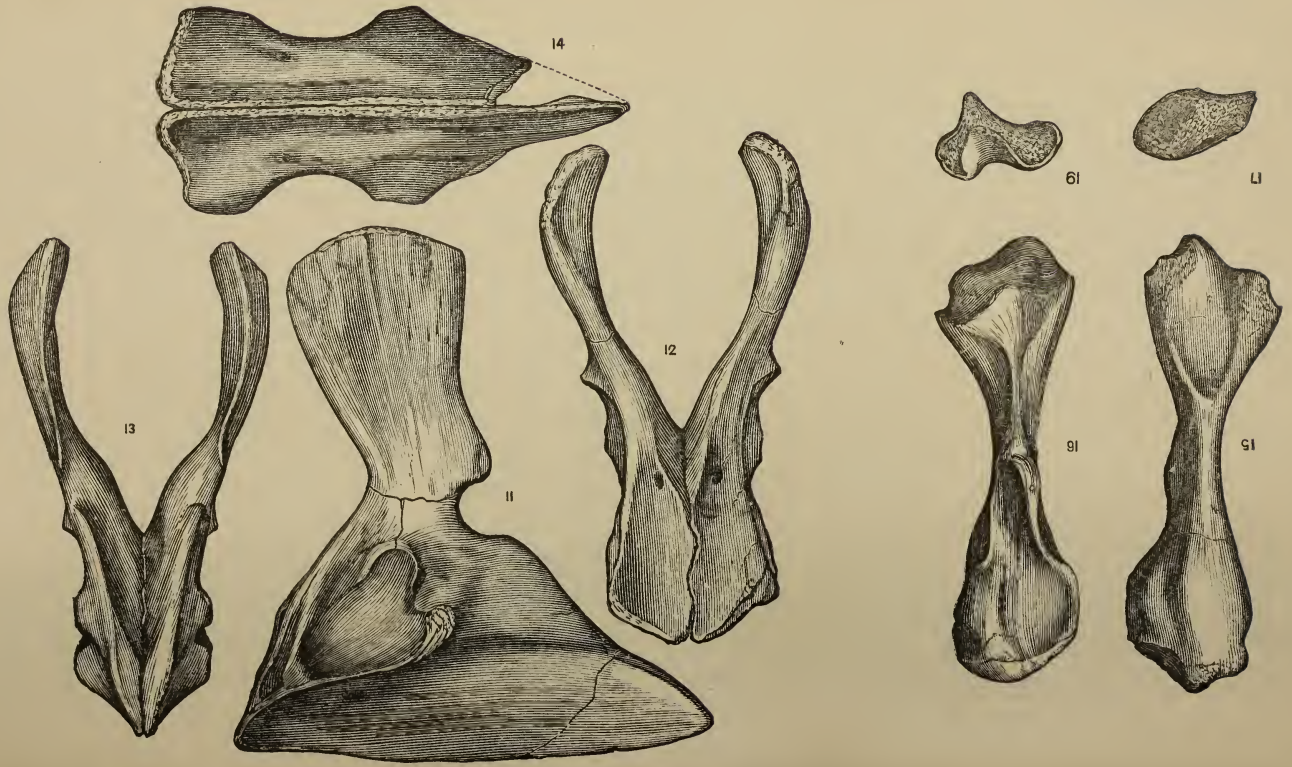


FIG. 5.—*Eryops megacephalus* Cope, skull from above, one-fifth nat. size.

dant, constituting with the reptilian genus Dimetrodon, the most prominent type of the Permian fauna in this country. The vertebral column is slender when compared with the size of the limbs, and especially of the head. The restoration of a species of European Labyrinthodon by Mr. Waterhouse Hawkins does not badly represent this species. The *E. reticulatus* Cope, is a much smaller species, and the sculpture of the skull is



ERYOPS MEGACEPHALUS Cope. $\frac{1}{15}$

sharper and of a net-like pattern. The neural spines are not so much expanded at the apex. It has been found in the Permian beds of New Mexico. The *E. ferricolus* Cope, is a still smaller species, known from skulls from Texas. This, with the *E. megacephalus* and the *Trimerorhachis insignis*, were found by Mr. Jacob Boll, a naturalist of Dallas, Texas, who was a man of many accomplishments and an ardent explorer. He lost his life through

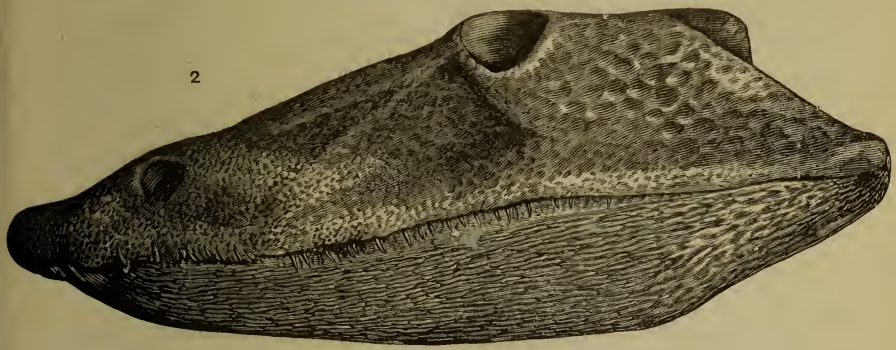


FIG. 6.—Side view of skull of *Eryops megacephalus*, one-fifth nat. size.

his indifference to his personal comfort while exploring the Permian beds at my instance.

ACHELOMA Cope.

This genus is allied to Eryops, and differs in two principal points. One of these is the absence of the lateral border of the cranial table formed by the external side of the *os intercalare* in Eryops and various other genera, the posterior outline of the skull being thus continuous. The other is the absence of the condyles of the humerus, a point in which it resembles Trimerorhachis. The vertebral segments are more robust than in Trimerorhachis, and less so than in Eryops; and it agrees with those genera in the absence of the mandibular angular process.

The only known species of this genus is the *A. cumminsi* from Texas. Its structure is pretty well known. It resembles in general the *Eryops megacephalus* with its small orbits and absence of lyrate groove, but is smaller and differs in various details. The skull is triangular and measures a little more than seven inches long by five wide, and has an open honeycombed sculpture of the surface. The vertebræ and limbs are small for the size of the skull; and in the former the summits of the neural spine are not expanded.

ANISODEXIS Cope.

This genus differs from those previously described, in the inequality in the sizes of the teeth of the external series. Thus in the upper jaw there is a very large one in the position of a canine, and in the lower jaw there are some large ones near the symphysis. The neural arch of the vertebræ resembles that of the genus Acheloma. The *A. imbricarius* Cope, is the only known species, and is represented in collections by fragments only. The size of its skull is nearly that of the *Eryops megacephalus*. The sculpture of the superior surface of the skull is a coarse reticulation; that of the sides of the jaws is of an imbricate or shingle-like character. The limbs are unknown. The vertebræ do not exhibit an expansion of the summit of the neural spine. From the Texas beds.

ZATRACHYS Cope.

This genus was originally represented by a maxillary bone, which supports teeth of equal length, and whose surface is extraordinarily rugose. In the typical species, *Z. serratus*, the rugosities project in the form of teeth along the external alveolar border. Individuals with sculptured neural spines and dermal bones are referred here. The intercentra are much like those of Eryops and Acheloma.

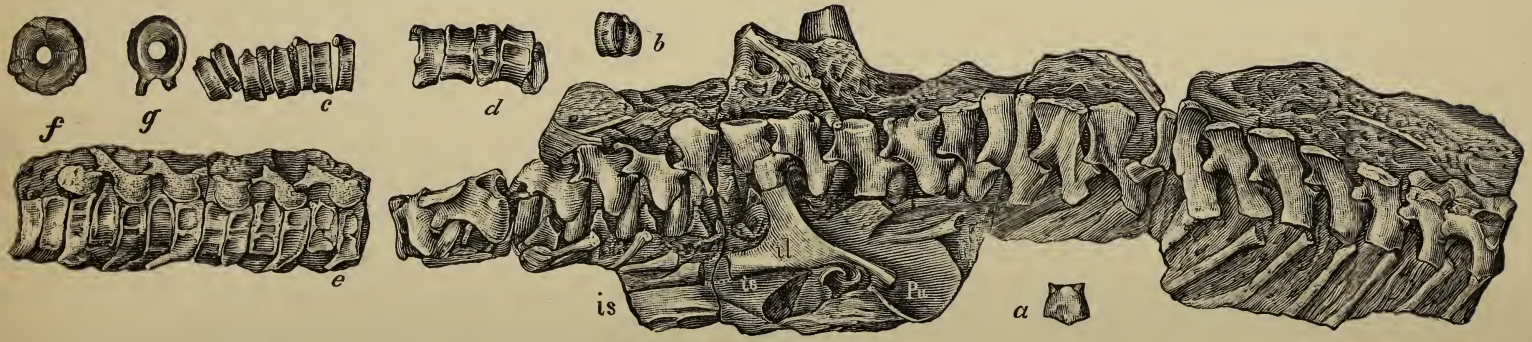
Two species are known, *Z. serratus* Cope, from Texas, and *Z. apicalis* from New Mexico. In the latter the neural spines have much expanded apices, with sculptured superior surfaces. The animal may have been four or five feet in length, while the *Z. serratus* could not have exceeded three feet. Both species were well protected from the assaults of the cotemporary carnivorous saurians by their dermoössifications.

EMBOLOMERI.

I proposed this order in 1880[1] to receive the family of the Cricotidæ. This remarkable form has been characterized in this journal[2] and elsewhere, by the complete development of its centra and intercentra, both of which form entire vertebral bodies which in pairs support single neural arches. No such character has been detected in the known divisions of the Stegocephali. Its

[1] AMERICAN NATURALIST, p. 610.

[2] Loc. cit. 1876, p. 405; 1878. p. 319. Proceedings Am. Philos. Soc., 1878, 523.



CRICOTUS HETEROCLITUS Cope. $\frac{2}{3}$.

characters were given as follows. I have not been able to expose the occipital condyle in my specimens.

Centra and intercentra subequally developed as vertebral bodies, a single neural arch supported by one of each, forming a double body. Chevron bones supported only by intercentra. Basioccipital vertebral articulation connected with the first vertebra by an undivided discoid intercentrum.

Thus the peculiarity of the vertebral column in general is carried into the cephalic articulation, and we have, instead of the complex atlas of the Rachitomi, a single body connecting the occipital condyle and first vertebra. This body represents, in all probability, *the single occipital condyle of the reptilian skull.* This part, as is well known, remains cartilaginous in the lizard long after the basioccipital is ossified,[1] and is a distinct element. In the Urodele Batrachia it appears, according to Albrecht, as the odontoid process of the *atlas.* The structure of Cricotus shows that it is a connate intercentrum. We have thus removed the last difficulty in the way of the proposition that the Reptilia are derivative of the Batrachia, viz., the difference in the cranio-vertebral articulation. But the former have not been derived from the Labyrinthodontia, as has been suggested, nor from the Rachitomi, but from the Embolomeri. The order of Reptilia which stands next to it is, of course, the Pelycosauria of the same period, which presents so many Batrachian characters, including intercentra, as I have for the first time pointed out in the paper above quoted.[2]

Professor Gaudry has been inclined to regard the bones which I have called intercentra as the true centra. But in the Embolomeri we have evidence that the pleurocentra are the true centra, since they assume the larger bulk, and support the neural arch and costal articulation, the intercentrum becoming more and more subordinate as we advance from the caudal series forwards. Moreover, the intercentrum bears the chevron bones in the Rhachitomi, and the Embolomeri, as they do in the cotemporary Pelycosauria.

I add to the ordinal characters above given, that the three pectoral shields of the Stegocephali are present here also.

[1] See Parker On the development of the skull of the Lizard, Philosophical Transactions, London, 1879.

[2] Intercentra remain in the cervical and dorsal series of Hatteria, and there is one at least in the cervicals of the Pythonomorpha.

Besides Cricotus, Fritsch describes a genus from Bohemia under the name Diplovertebron, which I suspect to belong to the Embolomeri.

In the family Cricotidæ the chorda dorsalis is persistent and large. The vertebral centra and intercentra are perforated so as to resemble some kinds of discoidal beads. They form a characteristic feature among the Permian fossils. The abdomen is protected by scales arranged in chevrons. There is a parietal foramen, and the supratemporal bone has a free external border like the squamosal of the crocodile.

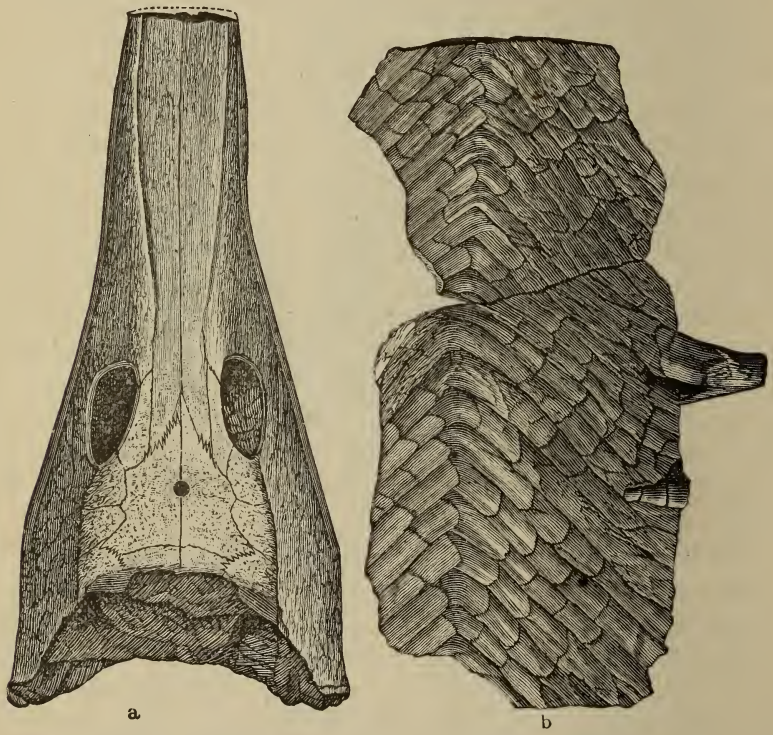


FIG. 7.—*Cricotus heteroclitus* Cope, the specimen figured on Plate v. Fig. *a*, skull from above, one-half nat. size, end of muzzle wanting; *b*, abdominal surface, showing scuta, distal extremity of femur and distal three phalanges of a digit, one-half nat. size.

CRICOTUS Cope.

In this genus the teeth are rather large, and are of subequal size in the external rows. The tail is long, and was apparently useful as a natatory organ. The terminal phalanges are obtuse as in salamanders, and without claws. The pelvis has the character of that of the Eryopidæ, but is less massive anteriorly. The

lower jaw has no posterior projecting angle. There are mucous grooves on the skull. The abdominal scales are oblong and in close contact with each other.

Cricotus heteroclitus was first found in Illinois, and afterwards in Texas. It is a more elongate animal than any of those described in the preceding pages, and it was furnished with short, rather stout limbs. It probably reached a length of ten feet, as my best preserved specimen, which is not the largest, measures about eight feet. It has an elongate triangular skull, eleven inches by six behind, with a singularly long, narrow, depressed muzzle, whose extremity overhangs the lower jaw completely. There are three pairs of mucous grooves; one is on each side of the roof of the muzzle, and runs out on the edge of the upper jaw, where it overhangs the extremity of the corresponding ramus. The second descends from behind the orbit, and running parallel to the edge of the upper jaw, joins the first at the usual position of a canine tooth in other forms. The third extends along the internal inferior edge of the mandibular ramus.

This species was probably aquatic in its habits. A smaller species, the *C. gibsoni*, has been described from Illinois. Its caudal vertebræ are of more elongate, cubical form than those of the *C. heteroclitus*.

EXPLANATION OF PLATES.

Plate II.

Eryops megacephalus Cope, vertebral column, one-fourth natural size, the upper figure from the left side, the lower figure from below. The four sections of the column represented are parts of the same individual.

Plate III.

Eryops megacephalus Cope, pelvic arch and femur, four-fifteenths natural size, belonging to the individual figured in Plate II. Figs. 11–14 pelvis; 11, left side; 12, front; 13, posterior view; 14, from below. Figs. 15–19, femur; 15, anterior view; 16, posterior view; 17, proximal view; 19, distal view.

Plate IV.

Trimerorhachis insignis Cope, part of vertebral column flattened by pressure, of probably one individual, natural size. The upper figures (except *b*) from the right side; the lower (except *d*) from below. Figs. *a–d*, atlas and axis, the former with double intercentrum; the latter with single intercentrum. Fig. *b*, anterior view; Fig. *d*, posterior view.

Plate V.

Cricotus heteroclitus Cope, part of skeleton of one individual, excepting Figs *f* and *g*, two fifths natural size. The vertebræ on the larger block include the posterior extremity of the dorso-lumbar series of the specimen as preserved, viewed partly from above. Fig. *a*, first cervical intercentrum, anterior face; *b*, the same attached to front of first cervical centrum, lateral view; *c*, four cervical centra separated by intercentra, partly from below; *d*, *e*, caudal vertebræ from below; caudal vertebræ from right side. Figs. *f* and *g*, specimens of the same from Illinois, anterior views; *f*, a dorso-lumbar intercentrum; *g*, a caudal intercentrum with bases of chevron bone; all two-fifths natural size.

15

On the Mutual Relations of the Bunotherian Mammalia.

By E. D. COPE.

[*From Proceedings of the Academy of Natural Sciences of Philadelphia, April 3, 1883.*]

ON THE MUTUAL RELATIONS OF THE BUNOTHERIAN MAMMALIA.

BY E. D. COPE.

The name Bunotheria was proposed by me for a series of Mammalia which resemble in most technical characters the Edentata and the Rodentia. That is, they agree with these orders in having small, nearly smooth cerebral hemispheres, which leave the olfactory lobes and cerebellum entirely exposed, and in some instances the hemispheres do not cover the mesencephalum also. From the two orders in question, however, they are easily distinguished. Their enamel-covered teeth separate them from the Edentata, while the articulation of the lower jaw is different from that found in the Rodentia. It is a transverse ginglymus, with a postglenoid process in the *Bunotheria*, as distinguished from the longitudinal groove, permitting anteroposterior motion, of the Rodentia.

Such a group as is thus characterized will include two existing groups recognized as orders—the Prosimiæ and the Insectivora. The latter group has always been a crux to systematists, and when we consider the skeleton alone, as from the standpoint of the palæontologist, the difficulty is not diminished. Various extinct types discovered in latter years, chiefly in the Eocene formations, have been additions to this intermediate series of forms, giving even closer relations with the orders already adjacent; *i. e.*, the Edentata, the Rodentia, the Prosimiæ, and the Carnivora. As is known, the groups corresponding to these orders have been named respectively the Tæniodonta, Tillodonta, Mesodonta, and Creodonta. With great apparent diversity, these suborders show unmistakable gradations into each other and the two recent orders already mentioned. As such, I may mention *Psittacotherium*, which relates the Tæniodonta and Tillodonta; *Esthonyx*, which relates the Tillodonta with nearly all the other suborders; *Achænodon*, which connects Creodonta and Mesodonta, and *Cynodontomys*, which may be Mesodont or Prosimian. Then the existing *Chiromys* most certainly connects Tillodonta and Prosimiæ.

My original definitions of the suborders of the Mesodonta, given in vol. ii of the U. S. Geological Survey under Capt. G. M. Wheeler, p. 85, omitted the Prosimiæ, and embraced a number

of characters whose significance must be reëxamined. Thus it is impossible to characterize the Creodonta as lacking a trochlear groove of the astragalus, in view of the form of that element in *Mesonyx* and *Mioclænus*, where the groove is more or less distinct. It is impossible to distinguish the Insectivora from the Creodonta by the deficiency of canine and large development of incisor teeth. In *Rhynchocyon* the canines are large, and the superior incisors wanting, while in *Centetes* the arrangement of these teeth is precisely as in the Creodonta. As to the large *Achænodon* and other *Arctocyonidæ*, I find no characters whatever to distinguish them from the generally small Mesodonta.

In view of these inconsistencies, I have reëxamined the subject, and find the following definitions to be more nearly coincident with the natural boundaries of the divisions of this large order. The importance of the character of the tritubercular superior molar has recently impressed me (see Proceedings of the Academy, 1883, p. 56), as it had previously done Prof. Gill. This zoologist has already distinguished two divisions of the Insectivora (without the *Galeopithecidæ*), by the forms of the superior molar teeth. The first possesses quadritubercular molars above, the second tritubercular. That these types represent important stages in the development of the molar dentition I have no doubt. These characters far outweigh in importance those expressing the forms of the skull, matters of proportion only, with which a few systematists unnecessarily overload their diagnoses. Such characters are of little more than specific value, and serve to obscure the mind of the inquirer for a true analysis. They may be used empirically, it is true, to determine relationships when the diagnostic parts are wanting.

I propose to transfer the Insectivora with tritubercular superior molars to the Creodonta, in spite of the fact that some of them (*Mythomys*, *Solenodon*, *Chrysochloris*) have but weakly developed canine teeth, and *Chrysochloris* has large incisors. As an extreme form, *Esthonyx* will follow, standing next the Tillodonta. It will then be necessary to transfer the Arctocyonidæ and all the Mesodonta to the Insectivora, where they will find affinity with the *Tupæidæ*. These have well-developed canines and small incisors, as in the extinct groups named. The *Chiromyidæ* must be distinguished from all of the other suborders, on account of its rodent-like incisors, combined with its lemur-like feet.

The characters of the five suborders will then be as follows:

I. Incisor teeth growing from persistent pulps:

Canines also growing from less persistent pulps, agreeing with external incisors in having molariform crowns; I. *Tæniodonta.*

Canines rudimental or wanting; hallux not opposable; II. *Tillodonta.*

Canines none; hallux opposable; III. *Daubentonioidea.*

II. Incisor teeth not growing from persistent pulps:

Superior true molars quadrituberculate; hallux opposable; IV. *Prosimiæ.*

Superior true molars quadrituberculate; hallux not opposable; V. *Insectivora.*

Superior true molars trituberculate or bituberculate;[1] hallux not opposable: VI. *Creodonta.*

While the above scheme defines the groups exactly, and, so far as can now be ascertained, naturally, I do not doubt but that future research among the extinct forms will add much necessary information which we do not now possess. It is possible that the group I called Mesodonta may yet be distinguished from the Insectivora by characters yet unknown. But I cannot admit any affinity between this group and any form of "Pachyderms," as suggested by Filhol, or of Suillines, as believed by Lyddeker.[2] Such suppositions are in direct opposition to what we know of the phylogeny of the Mammalia. These views are apparently suggested by the Bunodont type of teeth found in various Mesodonta, but that character gives little ground for systematic determination among Eocene Mammalia, and has deceived palæontologists from the days of Cuvier to the present time. The only connecting point where there may be doubt as to the ungulate or unguiculate type of a mammal is the family *Periptychidæ*, of the suborder *Condylarthra.* The suborder *Hyracoidea* may furnish another index of convergence.

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[1] The internal tubercle is wanting in the last two superior molars in *Hyænodon.* This genus, of which the osteology remains largely unknown, has been stated by Gervais to possess a brain of higher type than the Creodonta. Prof. Scott, of Princeton, is, however, of the opinion that this determination is erroneous, and that *Hyænodon* is a true Creodont in this and other respects. If so, the genus will perhaps enter the *Amblyctonidæ.*

[2] Memoirs Geological Survey India, Ser. x, 1883, p. 145.

The families included in these suborders will be the following:

TÆNIODONTA. *Calamodontidæ; Ectoganidæ.*

TILLODONTA. *Tillotheriidæ.*

DAUBENTONIOIDEA. *Chiromyidæ.*

PROSIMIÆ. *Tarsiidæ;* (?) *Anaptomorphidæ;* (?) *Mixodectidæ; Lemuridæ.*

INSECTIVORA. *Soricidæ; Talpidæ; Erinaceidæ; Macroscelidæ; Tupæidæ; Adapidæ;*[1] *Arctocyonidæ.*

CREODONTA. *Chrysochloridídæ; Esthonychidæ; Centetidæ* (= *Leptictidæ* olim); *Oxyænidæ; Miacidæ; Amblyctonidæ; Mesonychidæ.*

I at one time called this order by the name Insectivora, a course which some zoologists may prefer. But a name should as nearly as possible adhere to a group to which it was first applied, and whose definition has become currently associated with it. Such an application is correct in fact, and is a material aid to the memory. There are various precedents for the adoption of a new general term for a group composed of subordinate divisions which have themselves already received names.

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[1] Two species of *Pelycodus* must be removed from this genus and family, and be placed in the Creodonta with *Mioclænus*. They are the *P. pelvidens* and *P. angulatus*, which have the posterior inner tubercle of the superior molars, a mere projection of the cingulum. I place them in a new genus which differs from *Mioclænus* in the possession of an internal cusp of the fourth inferior premolar, under the name of *Chriacus;* type *C. pelvidens.*

In order to determine the number of internal tubercles in some of the *Insectivora*, so as to ascertain the affinities of some questionable genera, it is first necessary to examine the homologies of the cusps of the molar teeth. The opossums are characterized by the presence of three longitudinal series of tubercles on the superior molar. The homologies of these cusps are rendered clear by the character presented by the fourth superior premolar, where the anterior intermediate is wanting. The external cusps are really such, and are not developed from a cingulum external to the true external cusps, as appears at first sight to be the case with such animals as the *Talpidæ*. The intermediate cusps are really such, although the posterior looks like the apex of a V-shaped external cusp. In *Peratherium* the external cusps are smaller than in *Didelphys*, and the intermediate V's so much better developed, that the type is much like that of the *Talpidæ*, in whose neighborhood I originally referred it.

This leads to a consideration of the question of the homologies of the cusps in the genera of the old order of *Insectivora* proper, and of the *Creodonta*. Mr. St. George Mivart has briefly discussed the question, so far as relates to the former group.[1] He commences with the primitive quadrituberculate type presented by *Gymnura* and *Erinaceus*, and believes that the external cusps occupy a successively more and more internal position till they come to be represented by the apices of well developed V's, as in the ungulate types. The V's are well developed in several families, and in *Chrysochloris* the two V's are supposed to be united and to constitute almost the entire apex of the crown, while in *Centetes* the same kind of a V forms a still larger part of the crown.

I believe that these conclusions must be modified, in the light of the characters of various extinct genera, and of the genus *Didelphys*. In the first place there is an inherent improbability in the supposition that the external V's of the superior molars of the *Insectivora* have had the same origin as those of the *Ungulata*. The movements of the jaws in the two groups are different, the one being vertical, the other partially lateral. In the one, acute apices are demanded; in the other, grinding faces and edges. We have corresponding V's in the inferior dental series, and we regard those as produced by the connection of alternating cusps

[1] Journal of Anatomy and Physiology, ii, 138, figures.

by oblique ridges. In homologizing the superior cusps, we have as elements, two external, two intermediate, and two internal cusps. The first are opposite the external roots, and the anterior internal is opposite the internal root.

First, as regards *Centetes* and *Chrysochloris*. Besides the strained character of the hypothesis that supposes the V-shaped summit of the crown to represent two V's fused together, there is good evidence obtainable in support of the belief that the triangle in question is the usual one presented by the *Creodonta*.

This clearly consists of the two external and the anterior internal cusps united by angular ridges. The form is quite the same as in *Leptictis* and *Ictops*, and nearly that of *Deltatherium*, where the external cusps are present. *Centetes* and *Chrysochloris* only differ from these in that the external cusps are wanting. In addition, the latter genus presents a rudiment of the posterior inner tubercle, as is seen in *Deltatherium*. An explanation similar to this is admitted by Mr. Mivart to apply to the cusps of the inferior molar of *Centetes*. It remains to ascertain whether the cusp in this genus, *Chrysochloris*, etc., represents an intermediate or not.

Secondly, as regards the *Talpidæ* and *Soricidæ*, where the external V's are well marked. If we examine the external cusps in the genus *Didelphys*, we find that the posterior one becomes gradually more anterior in its position, until on the second true molar it stands largely above the interspace between the roots, instead of over the posterior root. It will also be seen that the anterior intermediate tubercle is distinct, and of insignificant proportions, while the posterior intermediate is large and is related to the posterior external, as is the apex of a V to its anterior base. In this arrangement I conceive that we have an explanation of the V's of the *Talpidæ* and *Soricidæ*. The first true molar of *Scalops* is a good deal like that of *Didelphys*, but the anterior cusp is larger and there is no anterior intermediate cusp, while the posterior external is of reduced size. The posterior V is better developed than in *Didelphys*, but is composed in the same way, of a posterior intermediate cusp, and a posterior external with a posterior heel. These are united by stronger ridges in *Scalops*, *Condylura* and *Blarina*, than in *Didelphys*. On the second true molar in *Scalops*, a V represents the anterior external cusp of the first true molar. Whether this V has a con-

stitution like the posterior one, *i. e.*, is composed of external and intermediate cusps joined, is difficult to determine; but it is probably so constituted. It seems to be pretty clearly the case in *Blarina*, where the fourth premolar and first true molar may be compared, with a resulting demonstration of the correctness of this view. In *Condylura*, the V's have become more developed and the external cusps reduced, so that the analysis is more difficult.

This interpretation applied to *Urotrichus* and *Galeopithecus* gives them quadrituberculate molars, not trituberculate, as determined by Mivart. *Mystomys* is tritubercular. The intermediate tubercles are present, but are imperfectly connected with the external, so that V's are not developed (*vide* figures of Mivart and Allman). This genus offers as much confirmation of the homology here proposed as do the opossums, but it differs from the latter in having the anterior intermediate tubercle the larger, instead of the posterior. *Mystomys* and *Solenodon* also confirm my determination of the homologies in *Centetes*.[1]

In conclusion I give the following synoptic view of the constitution of the superior molar teeth in various genera of the *Bunotheria*.

Cusps Present.

External. Intermediate. Two internal.	External. No intermediate. Two internal.	External. Intermediate One internal.	External. No intermediate. One internal.	No external. No intermediate. Two internal.	No external. No intermediate. One internal.
Adapidæ.	Gymnura.	Mystomyidæ	Mesonyx.	Chrysochloris (2d internal rudimentary)	Centetes.
Tupæidæ.	Erinaceus.	Mioclænus.	Leptictis.		
Galeopithecidæ	Macroscelididæ	Miacis.	Stypolophus.		
Soricidæ.		Talpidæ.	Oxyæna.	Solenodon. (do.)	
Urotrichus.		(Didelphys.)	Chriacus.		
		(Canis.)	Deltatherium		
			Esthonyx. (2nd internal rudimentary)		

[1] This view was first advanced by the writer in the Annual Report U. S. Geol. Survey Terrs., 1873 (74), p. 472.

16

THE

STRUCTURE AND APPEARANCE

OF A

LARAMIE DINOSAURIAN.

By Prof. E. D. Cope.

From the American Naturalist, July, 1883.

(*From the American Naturalist, July, 1883.*)

GEOLOGY AND PALÆONTOLOGY.

THE STRUCTURE AND APPEARANCE OF A LARAMIE DINOSAURIAN. —During the expedition of 1882 Messrs. Wortman and Hill discovered in the Laramie formation of Dakota, the nearly entire skeleton of a gigantic herbivorous land-saurian. On investigation it proves to be the *Diclonius mirabilis* of Leidy. The genus Diclonius Cope, is one of the Hadrosauridæ, and differs from Hadrosaurus in the coössification of the astragalo-calcaneum with the tibia. The Hadrosauridæ present the characters of the sub-order Orthopoda (Stegosauria and Ornithopoda Marsh). I give an account of the osteology of the skull, together with some systematic conclusions, in the Proceedings of the Philadelphia Academy for 1883, p. 97. The present notice recites a few of the points of that article.

According to Mr. Wortman the total length of the skeleton is thirty-eight feet. The skull measures 1.180 meters. The general form and appearance of the skull, as seen in profile, is a good deal like that of a goose. From above it has more the form of a rather short-billed spoonbill (Platalea). For a reptile the head is unusually elevated posteriorly, and remarkably contracted at the anterior part of the maxillaries. The flat, transverse expansion of the premaxillaries is absolutely unique. The posterior edges

of the occipital bones are produced far backwards, forming a thin roof over the anterior part of the vertebral column.

The orbit is posterior in position, and is a horizontal oblong in form. The superior (superciliary) border is flat, with slight rugosities at the positions of the pre- and postfrontal sutures. The frontal region is a little concave, and there is a convexity of the superior face of the prefrontal bone in front of the line of the orbit. The peculiar position of the teeth gives the side of the face, when the mandible is closed, a horizontally extended concavity.

The dentition is remarkable for its complexity, and for the difference in character presented by the superior and inferior series. Leidy pointed out the character of the latter[1] in the *Hadrosaurus foulkei*, and I have described the character of the superior dentition in the genera Cionodon[2] and Diclonius[3]

As compared with the *Hadrosaurus foulkei*, the dental magazine is much deeper, and contains a greater number of teeth in a vertical column, and probably a larger number in the aggregate. I find in each maxillary bone of the *Diclonius mirabilis*, six hundred and thirty teeth, and in each splenial bone, four hundred and six teeth. The total number is then two thousand and seventy-two.

The greater part of the external and inferior faces of the ramus of the lower jaw is formed by the surangular bone, which has an enormous extent, far exceeding in size that of any known reptile. It extends posteriorly to below the quadrate cotylus. Anteriorly it spreads laterally and unites with its fellow of the opposite side, forming a short symphysis and simulating a dentary. In correspondence with this extent of the surangular, the splenial is enormously developed, and contains the great magazine of teeth which I have described as characteristic of this type.[4] Its internal wall is very thin, and adheres closely to the faces of the teeth, in the fossil, in its present condition. This development and dentition of the splenial bone distinguishes the Hadrosauridæ widely from the Iguanodontidæ. The dentary bone is a flat, semicircular plate attached by a suture to the extremities of the surangulars. There is no trace of symphysial suture, and the posterior border sends a median prolongation backwards, which is embraced by the surangulars. The edge of the dentary is flat, thin and edentulous, and closes within the edge of the premaxillary.

Dermal or corneous structures have left distinct traces in the soft sandstone about the end of the beak-like muzzle. Laminæ of brown remnants of organic structures were exposed in re-

[1] Cretaceous Reptiles North America, 1864, p. 83.

[2] Vertebrata of Cretaceous formations of the West, 1875, p. 59.

[3] Proceedings Philadelphia Academy, 1876, p. 250.

[4] Bulletin Geological Survey of the Territories. F. V. Hayden, III, pp. 594–7, May, 1877.

moving the matrix. One of these extends as a broad vertical band round the sides, indicating a vertical rim to the lower jaw, like that which surrounds some tea trays, and which probably represents the tomia of the horny sheath of a bird's beak. At the front of the muzzle its face is sharply undulate, presenting the appearance of vertical columns with tooth-like apices. Corresponding tooth-like processes, of much smaller size, alternate with them from the upper jaw. These probably are the remains of a serration of the extremital part on the horny tomia, such as exist on the lateral portions in the lamellirostral birds.

General affinities.—The structure of the skull of this species adds some confirmation to the hypothesis of the avian affinities of the Dinosauria, which I first announced, as indicated by the hind limbs, and which Professor Huxley soon after observed in the characters of the limbs and pelvis. The confirmation is, however, empirical rather than essential, and is confined to a few points. One of these is the form and position of the vomer, which much resembles that seen in lamellirostral birds. The large development of the premaxillary bone has a similar significance. So has the toothless character of that bone and the dentary.

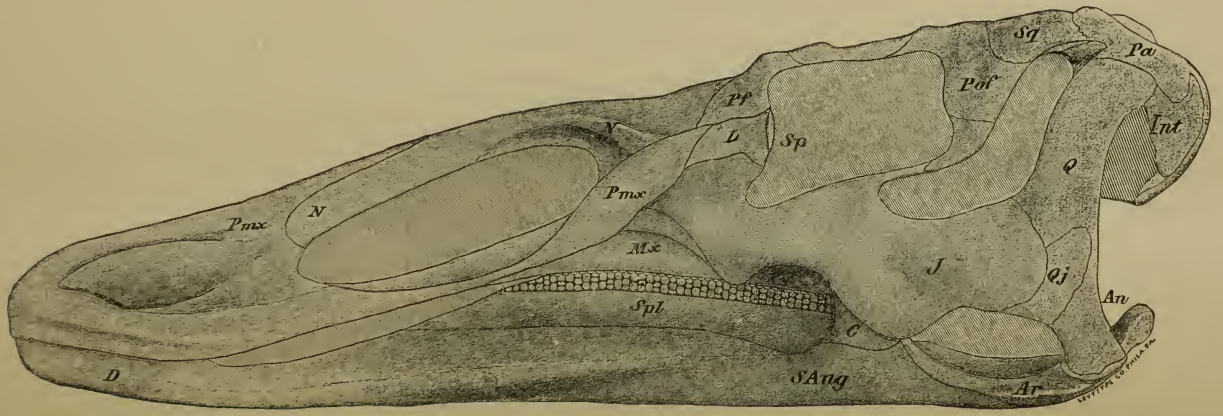
Among reptiles this skull combines, in an interesting way, the characters of the two orders Crocodilia and Lacertilia. The extension of the premaxillary (which may be continuous with the maxillo-turbinal) above the maxillary, so far as to overlap the lachrymal, is unique among Vertebrata, so far as I am aware. The free exoccipito-intercalare hook is scarcely less remarkable.

Of mammalian affinity no trace can be found.

Restoration.—This animal in life presented the kangaroo-like proportions ascribed by Leidy to the *Hadrosaurus foulkei.* The anterior limbs are small, and were doubtless used occasionally for support, and rarely for prehension. This is to be supposed from the fact that the ungual phalanges of the manus are hoof-like, and not claw-like, though less ungulate in their character than those of the posterior foot. The inferior presentation of the occipital condyle shows that the head was borne on the summit of a vertical neck, and at right angles to it, in the manner of a bird. The head would be poised at right angles to the neck when the animal rested on the anterior feet by the aid of a U-like flexure of the cervical vertebræ. The general appearance of the head must have been much like that of a bird.

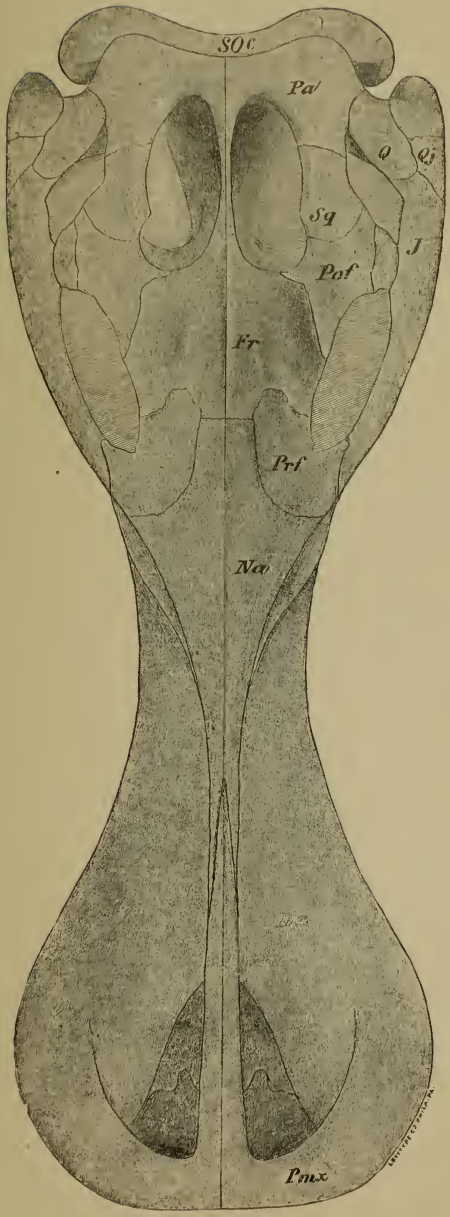
The nature of the beak and the dentition indicate, for this strange animal, a diet of soft vegetable matter. It could not have eaten the branches of trees, since any pressure sufficient for their comminution would have probably broken the slightly attached teeth of the lower jaw from their places, and have scattered them on the floor of the mouth. It is difficult to understand also how such a weak spatulate beak could have collected or have broken off boughs of trees. By the aid of its dentate horny edge it may

PLATE XVI.



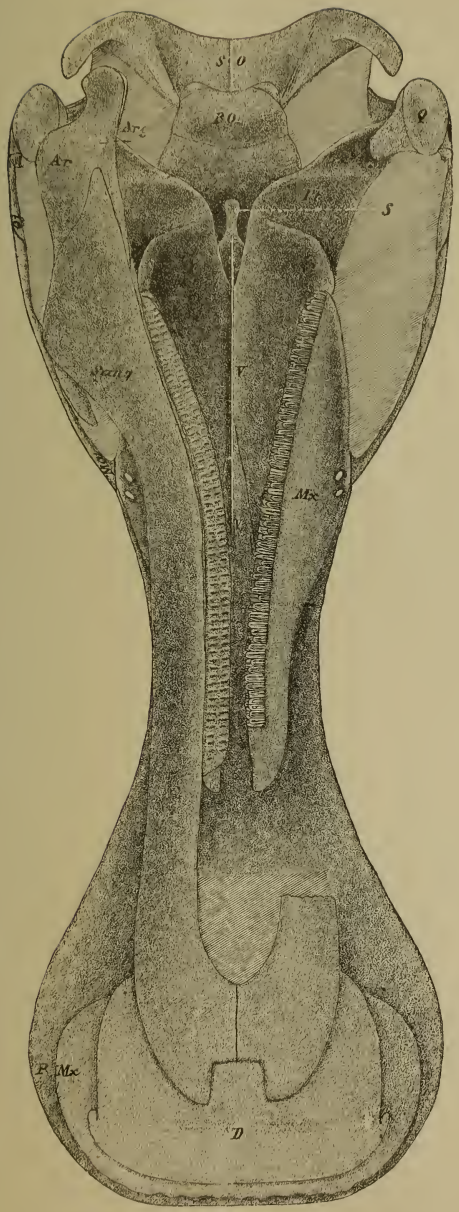
Diclonius mirabilis, one-seventh nat. size.

PLATE XVII.



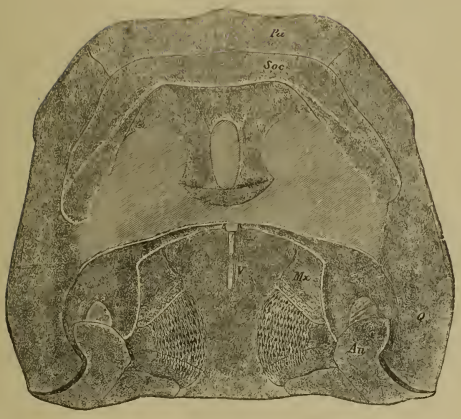
Diclonius mirabilis, one seventh nat. size.

PLATE XVIII.



Diclonius mirabilis, one-seventh nat. size.

PLATE XIX.



Diclonius mirabilis, one-seventh nat. size; posterior and anterior extremities of skull.

have scraped leaves from the ends of branches, but the appearances indicate softer and less tenacious food. Could we suppose that the waters of the great Laramie lakes had supplied abundant aquatic plants without woody tissue, we would have the condition appropriate to this curious structure. Nymphæas, Nuphars, Potamogetons, Anacharis, Myriophyllum, and similar growths, could have been easily gathered by this double spoon-like bill, and have been tossed, by bird-like jerks of the head and neck, back to the mill of small and delicate teeth. In order to submit the food to the action of these vertical shears, the jaws must have been opened widely enough to permit their edges to clear each other, and a good deal of wide gaping must, therefore, have accompanied the act of mastication. This would be easy, as the mouth opens, as in reptiles and birds generally, to a point behind the line of the position of the eye. The eye was evidently of large size. The coronoid process of the mandible encroaches on the orbit below, and the temporal muscle evidently did so posteriorly. It is probable, as suggested to me by Mr. Geismar, that in the act of mastication the eye was alternately protruded and retracted with the contraction and extension of the temporal muscle. The indications are that the external ear was of very small size. There is a large tract that might have been devoted to the sense of smell, but whether it was so or not is not easily ascertained.

We can suppose that the long hind legs of this genus and of Hadrosaurus were especially useful in wading in the waters that produced their food. As Dollo has shown that the muscles of the fourth trochanter (third trochanter Auctorum) are attached to the proximal caudal vertebræ, one can see the huge tail swing from side to side with each advancing step, and create a great swirl in the water. When the bottom was not too soft, they could wade to a depth of ten or more feet, and, if necessary, drag aquatic plants from their hold below. Fishes might have been available as food when not too large, and not covered with bony scales. Most of the fishes of the Laramie period are, however, of the latter kind (genus Clastes). The occurrence of several beds of lignite in the formation shows that vegetation was abundant.

EXPLANATION OF PLATES.

(All are one-seventh natural size.)

PLATE XVI. Side view of the skull of *Diclonius mirabilis*.

" XVII. The same viewed from above.

" XVIII. Inferior view of the same.

" XIX, Fig. 1. View of occipital region of the same. Fig. 2. View of the extremity of the muzzle from the front.

The complete iconography of this species will appear in the Report of the United States Geological Survey, under J. W. Powell, now in course of preparation.

—*E. D. Cope.*

PRINTED July 21, 1883.

(17)

THE

Systematic Arrangement

OF THE

ORDER PERISSODACTYLA,

WITH A NOTE ON THE

STRUCTURE OF THE FOOT OF TOXODON.

BY E. D. COPE.

(*Read before the American Philosophical Society, April 15, 1881.*)

The Systematic Arrangement of the Order Perissodactyla. By E. D. Cope.

(*Read before the American Philosophical Society, April* 15, 1881.)

PERISSODACTYLA.

This, the second great order of the ungulate Mammalia, naturally occupies a position between the *Amblypoda* and the *Artiodactyla*. Its lower forms are more specialized in the structure of the feet than the *Amblypoda*, while its highest types do not reach the perfection of structure seen in the *Artiodactyla*. This is particularly indicated by the form of the astragalus, which has but one, the tibial trochlea, and never displays the distal one characteristic of the cloven-footed families. The *Perissodactyla* occupy, as regards their dentition, a position parallel with the *Artiodactyla*. They are always superior in dental complication to the *Proboscidia* and the suilline *Artiodactyla*, but only one series, that of the horses, reaches the com-

plexity of molars general in the *Ruminantia*. The dentition of the mass of the *Perissodactyla* might be described as intermediate between that of the *Proboscidia* and the lowest selenodont *Artiodactyla*.

The families of this order form a closely connected series, and the division of them into three divisions, the "Pachydermata," "Solipeda" and *Perissodactyla*, has no warrant in nature. Especially unnatural is the conjunction of the genera included under the first name, with the *Proboscidia* and certain suilline *Artiodactyla*, in a single order, as was proposed by Cuvier. The modifications of dentition from the simple type seen in *Menodus*, to the most complex, as in *Equus*, are close and consecutive. So, also, the gradual diminution in the number of digits from 5–4 to 1–1 can be traced through all the intervening stages.

The following definitions of families are applicable in the present stage of knowledge. Those of all but three were published in the Bulletin of the U. S. Geological Survey of the Territories, 1879, p. 228. A modification in the diagnoses of the families *Chalicotheriidæ* and *Palæotheriidæ* is now introduced:

I. Anterior exterior crescent of superior molars shortened, not distinguished from the posterior by external ridge; inferior molars with cross-crests; premolars different from molars.

1. Toes 4–3 ..... *Lophiodontidæ*.
2. Toes 3–3 ..... *Triplopodidæ*.

II. Exterior crescents of superior molars as in I; inferior molars with cross-crests; superior molars and premolars alike, with cross-crests.

3. Mastoid bone forming part of the external wall of the skull ..... *Hyracodontidæ*.
4. Mastoid bone excluded from the walls of the skull by the contact of the occipital and squamosal ..... *Rhinoceridæ*.

III. Exterior crescentoid crests of superior molars subequal, distinct; inferior molars with cross-crests.

5. Superior molars and premolars alike and with cross-crests; toes 4–3... *Tapiridæ*.

IV. The external crescentoid crests of the superior molars subequal, separated by an external ridge; inferior molars with crescents.

A. Superior premolars different from molars; with only one internal cusp.

6. Toes 4-3; a vertebrarterial canal ..... *Chalicotheriidæ*.
7. Toes 3–3; no vertebrarterial canal ..... *Macraucheniidæ*.

AA. Premolars like molars, with two internal lobes above.

8. Toes with digits, 4–3 ..... *Menodontidæ*.
9. Toes with digits, 3–3 ..... *Palæotheriidæ*.
10. Toes with digits, 1–1 ..... *Equidæ*.

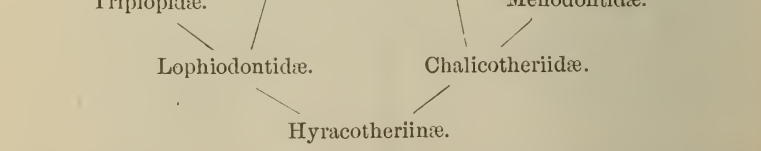
The genera included in these families are the following. The table shows their geological distribution :

	EOCENE.		MIOCENE.			PLIOCENE.	RECENT.
	Lower	Upper	Lower	Middle	Upper		
Lophiodontidæ.							
Hyracotherium Ow.	12						
Pliolophus Ow.	4	2					
? Lophiotherium Gerv.		1					
Pachynolophus Pom.	3	3					
Helaletes Marsh		3					
Lophiodon Cuv.	2	11					
Hyrachyus Leidy		9					
Colonoceras Marsh		1					
Triplopidæ.							
Triplopus Cope		2					
Hyracodontidæ.							
Hyracodon Leidy			2				
Rhinocerontidæ.							
Aceratherium Kaup			3				
Cœnopus Cope			2				
Diceratherium Marsh				3			
Zalabis Cope							
Aphelops Cope					4		
Ceratorhinus Gray				1	2		2
Rhinocerus Linn.					4		2
Peraceras Cope					2		
Atelodus Pom					2	1	2
Cœlodonta Bronn						3	
Tapiridæ.							
Listriodon Gerv				? 3			
Tapirus Linn.						6	5
Elasmognathus Gill							1
Chalicotheriidæ.							
Rhagatherium Pict	1						
Leurocephalus S. S. and O.		1					
Palæosyops Leidy	1	5					
Limnohyus Leidy		3					
Lambdotherium Cope	2	1					
Propalæotherium Gerv	1	2					
Chalicotherium Kaup.		3					
Nestoritherium Kaup				? 1			
Meniscotherium Cope	1						
Macrauchenidæ.							
Macrauchenia Ow.					2		

	EOCENE.		MIOCENE.			PLIOCENE.	RECENT.
	Lower	Upper	Lower	Middle	Upper		
Menodontidæ.							
Acoëssus Cope	1						
Diplacodon Marsh		1					
Menodus Pom			2				
Symborodon Cope			6				
Dæodon Cope				1			
Palæotheriidæ.							
Anchilophus Gerv		2					
Paloplotherium Ow		6					
Palæotherium Cuv		3					
Mesohippus Marsh			2				
Anchitherium Kaup			2	4			
Anchippus Leidy				1	1		
Hippotherium Kaup					8	1	
Protohippus Leidy					5	1	
Equidæ.							
Hippidium Owen					2	3	
Equus Linn						5	7

Total number of well determined species, one hundred and eighty-nine.

From the preceding table it can be readily seen that this order was abundantly represented during the Eocene period, and that the recent species are comparatively few. It may also be observed that certain families predominated during certain periods. Thus the prevalent *Perissodactyla* of the Eocene are *Lophiodontidæ* and *Chalicotheriidæ;* those of the Miocene are *Rhinocerontidæ* and *Palæotheriidæ.* The *Tapiridæ* and *Equidæ* characterize the latest tertiary epochs. A genealogical tree of the order may be constructed as follows :



The types of the *Lophiodontidæ* and *Chalicotheriidæ* differ only in the two

points of the separation, or non-separation, of the exterior crescents of the superior molars, as already pointed out. That no great modification of known forms (as *Lambdotherium* in the *Chalicotheriidæ*, and *Hyracotherium* in the *Lophiodontidæ*) would be necessary to obliterate this difference, is quite clear. The parent types of the order, which present the most generalized dentition, *Hyracotherium*, *Rhagatherium*, and *Acoëssus*, were cotemporaries of the Lower Eocene epoch.

LOPHIODONTIDÆ.

This family embraces a larger number of known species than any of the others of the order. With one exception, all the species belong to the Eocene period. They range from the size of a rabbit to that of an ox. They resembled most, among living animals, the tapirs.

The genera are characterized as follows :—

I. External lobes of superior molars well separated and little flattened; lobes of inferior molars scarcely united (*Hyracotheriinæ*).

A. No diastema behind first premolar.

a. Third and fourth inferior premolar like the first true molar.

Last inferior molar with five lobes ..... *Lophiotherium*.

AA. A diastema behind the first premolar in both jaws.

a. Last inferior premolar different from first true molar;

Last inferior molar with heel; cross-crests of superior molars interrupted; *Hyracotherium*.

aa. Last inferior premolar like first true molar;

True molars as in *Hyracotherium* ..... *Pliolophus*.

II. External lobes of superior molars flat, not well distinguished. (*Lophiodontinæ*.)

"*A*. No diastema in lower jaw.

Last inferior molar with third lobe ..... *Helaletes*."

AA. Lower jaw with diastema.

*No diastema behind first premolar.

a. No inferior premolars like the true molars.

Superior molars 7.

Last inferior molar with heel ..... *Pachynolophus*.

Superior molars 6;

Last inferior molar with heel ..... *Lophiodon*.

Last lower molar without heels, no horns ..... *Hyrachyus*.

Last lower molar?; "an attachment for a dermal horn on each nasal bone" ..... *Colonoceras*.

The geographical range of these genera is as follows :—

North America only ..... *Helaletes*, *Colonoceras*.

North America and Europe ; *Pachynolophus, Hyrachyus, Hyracotherium, Pliolophus.*

Europe only ; *Lophiodon, Lophiotherium.*

Four of the genera ascribed to North America have come under my observation.

TRIPLOPIDÆ.

Cope, American Naturalist, 1881, April (March 25th), p. 340.

But one genus of this family is known at present, but the number will probably be increased when the structure of the feet of various imperfectly known species is ascertained.

Fig. 1. Part of right maxillary bone of *Pachynolophus singularis* Cope; from the Wasatch beds of New Mexico, from Capt. Wheeler's report iv ii pl. lxvi.

TRIPLOPUS Cope.

American Naturalist, 1880, p. 383 (April 27th).

Dental formula, I. ? ; C. $\frac{1}{1}$; P–m. ; $\frac{4}{4}$; M. $\frac{3}{3}$; a considerable diastema anterior to the first premolar. Molars with only two vertical external ridges, the anterior cingular and the approximated median of the anterior crescent. Transverse crests two, uninterrupted and rather oblique ; a ? third and short crest, on the posterior base of the first true molar. Premolars different from molars, the third and fourth with two transverse crests. Inferior molars with two transverse crests, as in *Lophiodon*, the last without heel.

An ossified inferior wall of the meatus auditorius externus. Posttympanic and paroccipital processes distinct form each other. No postorbital arch. Postparietal and mastoid foramina preserved ; the latter large. Cervical vertebræ rather long ; axis with subcylindric odontoid process. Scapula with small coronoid process. Great tuberosity of humerus long, curved. No trochlear crest on condyles of humerus ; epicondyles rudimental. Ulna and radius distinct throughout their length ; ulnar articulation with carpus, small. Trapezoid bone of carpus with a facet for the trapezium. Unciform with two inferior facets. Metacarpals three principal ones, and one, the fifth, rudimental ; the distal extremities of the second and fifth opposite ; the third a little longer.

The dentition of this genus is nearly that of *Hyrachyus*. The only exception is the possible third transverse crest of the first true molars*. The other portions of the skeleton known, are also much like those of *Hyrachyus*, with the exception of the number of digits of the anterior foot. The entirely rudimental character of the fifth metacarpal, which with its

*This point is further considered in the description of the species.

digit, is so well developed in *Hyrachyus*, places *Triplopus* in another family, and in another line of descent. I think that it must be regarded as one of the forms of the series connecting the tapirs with the rhinoceroses. The fourth digit (the fifth) was retained by the earliest type of rhinoceros in Europe, the genus *Aceratherium*, but in America it appears to have been lost earlier. None of the American rhinoceroses of the Lower Miocene of the genus *Cœnopus* Cope present it, and in the present genus we have an ancestral type of the Eocene period, in which the last digit is already lost. The premolars of different structure from the true molars, exclude this genus from the *Rhinocerontidæ*, and with the character of the feet place it between that family and the *Lophiodontidæ*.

As yet, but one species of *Triplopus* is certainly known, but a second is placed in it provisionally.

TRIPLOPUS CUBITALIS Cope.

American Naturalist, 1880, p. 383.

This species is represented by a nearly entire skull with lower jaw; most of the cervical vertebræ; a left anterior limb nearly complete; a part of the left scapula, and a part of the right anterior limb; all belonging to one animal. The specimen was not quite adult, as the last superior molar is just protruding its crown through the maxillary wall, and the last two superior milk premolars still remain in place, much worn and closely pressed by the overlying successional teeth.

The *cranium* is peculiar in its wide orbital region, and short compressed muzzle; the latter is damaged in the specimen so that the form of the nasal bones cannot be determined, except at their proximal portions. The interorbital space is plane in both directions, and rises very gently posteriorly. The sagittal crest is narrow and low, until above the meatus auditorius, where it rises. Above the posttympanic process it bifurcates, and each rounded lateral lobe extends posteriorly to a point above the occipital condyles. Viewed from above the head is wide between the zygomatic fossæ, and at the posterior premaxillary teeth. The top of the muzzle narrows rapidly above the latter, but does not contract below until the first premolar is reached. The zygomatic arch is not convex along its middle, and encloses a narrow fossa. The superciliary border is prominent, and nearly straight, and is bounded by a notch behind. The squamoso-occipital ridge is well marked. The posttympanic process is shorter than the paroccipital, and is separated from it by an open shallow groove, which is probably bottomed by the mastoid bone. The paroccipital process is much narrowed below and is turned a little outwards. There are two closely adjacent tubercles on the anterior border of the orbit, probably on the lachrymal bone.

Foramina. Only a few of these are well preserved; among the lost is the *f. infraorbitale*. There are two postparietal foramina on one side, and one on the other, above the point of origin of the zygomatic process of the squamosal bone; and one in the usual posterior position. The post-squamosal has the same anterior position as the anterior postparietals,

being immediately below them ; I cannot discover whether there is a posterior one or not owing to injuries to the specimen. There is apparently a fissure-like one on the parieto-squamosal suture posteriorly. The mastoid is quite large, expanding downwards and outwards ; it is not so large as in a tapir, but much exceeds that in *Hyrachyus eximius*. The *meatus auditorius externus* is large, and occupies only the posterior part of the space between the postglenoid and posttympanic processes. It is enclosed anteriorly and below by the border of a wide element which may be tympanic. It encloses the petrous bone below in a bulla ; as however the inner portion of the best preserved one is broken away, I cannot speak of its relations to the basioccipital bone. The *foramen lacerum posterius* is reduced to a jugular and perhaps another connected foramen by the close apposition of the petrous bone to the basioccipital for a considerable distance. The region of the *f. l. medius* is injured. Posterior to the *f. l. posterius* is a foramen opposite the base of the paroccipital process, anterior to the usual position of the *f. condyloideum*.

Mandible. The angle of the lower jaw is produced posteriorly, as in some species of *Hyrachyus:* cfr. figs. Vol. IV, U. S. Geol. Surv. Terrs. The coronoid process is long and is curved backwards to above the posterior border of the condyle. There is no tuberosity behind the condyle. The symphysis is quite contracted and is short. The mental foramen is below the middle of the inferior diastema. The ramus is compressed and at the same time strong.

Dentition. As the deciduous third and fourth premolar teeth, in a worn condition, remained in the maxillary bone, I removed them from one side, thus displaying the crowns of the corresponding permanent teeth. The first premolar may belong to the permanent dentition; the second is the deciduous. The former has two roots. The crown is cutting for a short distance anteriorly, but posteriorly it expands into a heel, much less developed than the internal lobe of the succeeding teeth. The crowns of the third and fourth premolars differ externally, as well as in their crests, from those of the true molars. The median-anterior and cingular vertical ridges are not so prominent as in the latter. The external crest is not divided into two by the notch in its grinding face. The anterior cross-crest, at its inner or distal extremity, is turned shortly backwards and then inwards, giving a "pot-hook" outline to its triturating surface. The fourth deciduous premolar presents a peculiar character already ascribed to the first true molar. This consists of a crest running parallel with the posterior transverse crest and close to it, along its posterior side. It forms the border of the tooth for a short distance, but as its direction is slightly obliquely forwards as well as outwards, the posterior cingulum appears for a very short distance.

The first true molar is subquadrate in outline. The anterior transverse crest commences at the middle-anterior ridge, and is first transverse, then directed a little obliquely backwards. The second crest commences at the apex of the posterior external crescent, leaving a wide posterior marginal

fossa. Its internal extremity is broken off. Posterior to, and in contact with it, the posterior cingulum rises in a crest, which occupies the internal half only of the border. Its inner border is imperfect. It appears to me to be probable that the normal posterior crest is turned posteriorly on itself so as to give the "pot hook" shape seen in the anterior crest of the fourth permanent premolar. The corresponding accessory crest in the fourth temporary premolar appears to have been distinct at its internal extremity. The second true molar has a more oblique posterior external crest, and the posterior internal is oblique and simple. It has narrow anterior and posterior basal cingula. There is no tubercle between the inner bases of the transverse crests of this or the last true molar. The latter is characterized by the rudimental character of the posterior external crescent crest, which is shortened like that of *Hyrachyus*. The transverse crests are curved backwards; the posterior is short and simple.

The canines are small, and are directed forwards. The extremity of the muzzle being broken, the relation of the incisors cannot be stated, but there was not probably any precanine diastema. An incisor preserved has the crown transversely expanded, and rather oblique.

The third and fourth inferior premolars are the deciduous ones, and are both three-lobed, but differ in the forms of the anterior lobe. In the third, it is narrow and incurved, as in the corresponding permanent teeth of some *Artiodactyla*. The transverse crests of the true molars are rather oblique, running forwards as well as outwards.

Their external extremities are bent at right angles, and there results a short descending crest running forwards and inwards; the anterior one turns inwards, again forming a transverse anterior ledge. No cingula on internal or external bases of crown; a rudimental posterior one.

Measurements of Cranium.	M.
Length from front of canine tooth to end of occipital condyles	.128
Length from same to postglenoid process	.096
" " " to end of last molar	.069
" " " to first premolar	.015
" " " to line of front of orbit	.044
Width between superciliary borders	.046
" of zygomata at orbits	.064
" of brain-case at glenoid surface	.048
" of occipital condyles	.023
" of basioccipital bone between *ossa petrosa*	.006
Distance between postglenoid and posttympanic processes	.014
Depth of occiput behind	.033
" of mandible from condyle	.040
" of mandibular ramus at third premolar	.014
" at diastema (axial)	.009
Least width of symphysis	.011

Measurements of Cranium.	M.
Diameter crown third permanent premolar { anteroposterior...	.007
Diameter crown third permanent premolar { transverse.	.005
Anteroposterior diameter crown first premolar.....	.0045
Diameters crown first true molar { anteroposterior.....	.010
Diameters crown first true molar { transverse	.012
Diameters crown second inferior true molar { anteroposterior	.011
Diameters crown second inferior true molar { transverse.	.0075
Diameter of root of inferior canine near crown.....	.0035

Vertebræ. The atlas is about as long relatively as that of the horse. Its transverse processes have more anteroposterior than transverse extent. The summit of the neural arch has a median ridge separating two grooves. The inferior surface of the centrum has a nearly median, obtuse hypapophysis. The axial facets are well separated below. The vertebrarterial canal pierces the base of the transverse process behind and below, and notches it deeply anteriorly. Above this notch the usual perforation of the arch is present. The axis is not relatively quite so long as that of the horse; it is a little longer than in *Hyrachyus eximius*, but rather shorter than in *Hyracodon arcidens* (Pl. CII, Fig. 7). The atlantal facets are spread well apart, and the articulating surface of the odontoid does not connect with them. The latter is rather long, is obtuse, and slightly recurved; it has no raised borders. Between the atlantal faces the inferior surface is plane. Posterior to this the middle line bears a prominent keel. The diapophyses are long, narrow and recurved, and each is pierced at the base by the vertebrarterial canal. The posterior articular face is but little concave, and a little oblique, and is a little wider than long.

The succeeding cervicals regularly diminish in length, and become more strongly opisthocœlous, the seventh having quite a ball in front. The sixth has a slender diapophysis directed posteriorly, and quite distinct from the wide and long parapophysis which is directed downwards and outwards. The posterior angle of the latter extends as far back as the centrum. The seventh has only a flat transverse diapophysis. The first dorsal has a very stout diapophysis excavated below for the rib tubercle. The diapophyses of the third and fourth dorsals are not so stout. The capitular fossæ are large. The centra of the anterior dorsals are flattened below; they are concealed in part by the matrix in this specimen. The neural spine of the sixth cervical is narrow, and is directed forwards. That of the seventh is vertical, and narrows rapidly from a base which is rather wide anteroposteriorly. The spines of the dorsals are wider, and are directed gently posteriorly; they are probably long, judging from the size of their bases.

Measurements of Vertebræ.	M.
Length centrum of atlas on side.....	.027
" " " below.....	.010
Width " " " posteriorly	.030

Measurements of Vertebræ.	M.
Width transverse process of atlas	.010
Vertical diameter neural and odontoid canal	.015
Length axis to odontoid process	.033
" odontoid process	.007
Diam. centrum behind vertical with hypapophysis	.012
Diam. centrum behind vertical without "	.009
Diam. centrum behind transverse	.0115
Length of centrum of fifth cervical	.030
" " seventh	.017
" " second dorsal	.014
Anteroposterior diameter of base of neural spine of second dorsal	.010
Expanse of head and tubercle of first rib	.012

Fore Limb.—The greater part of the blade of the scapula is lost. The neck is stout, and the coracoid is a short aliform process. The humerus is moderately robust, most so proximally. The greater tuberosity is a strongly incurved crest, with truncate summit, which is a little elevated above the plane of the head, from which it rises rather abruptly. The bicipital ridges are not strong nor prominent. The olecranar fossa is deeper than the coronoid fossa, and they communicate by perforation. The inner part of the condyle is the largest, and forms an acute angle with the interior epicondylar surface. The exterior part of the condyle is divided by an oblique angle of the surface separating an external bevelled band of the same, which narrows to extinction on the posterior side. As compared with the humerus of *Hyrachyus eximius*, that of *Triplopus cubitalis* is very similar, differing mainly in two points at the distal extremity. The olecranar fossa is smaller and is less excavated, and its lateral bounding ridges are of unequal elevation ; in *T. cubitalis* they are equal.

The ulna and radius are more than one-fourth longer than those of *H. eximius*. Although they are entirely distinct throughout, the ulna is quite slender anterior to the proximal third. The shaft is much more slender than that of *Hyrachyus eximius*. The olecranon is compressed, deep, and truncate behind. The distal epiphysis is remarkable for its length, being twice as long as that of the radius. The head of the radius is subequally divided by fossæ, the external being the shallower. The inferior or ulnar facet is regularly and gently convex downwards, and is bounded behind by a roughened ridge, which, near the external border turns backwards to the humeral border. The shaft of the radius is robust and flattened. The carpal facet of the radius is contracted, and has three times the superficial area of that of the ulna. The scapholunar dividing ridge is present, but is very low. The scaphoid face is the more excavated, and then rolls backwards, forming a very narrow posterior facet, which is narrower than that found in the species of *Anchitherium*. There is no distinct fossa on its inner or posterior border, as in many ungulates. The trapezium and scaphoid are the only bones of the carpus which are wanting. The latter

is probably wider than long or deep, while both the lunar and cuneiform are longer than wide. The cuneiform has not its external border excavated; its proximal surface is oblique and continuous, the ulnar and pisiform facets being in line. The pisiform is large, and is enlarged distally; its proximal facets are equal. The exposed face of the trapezoides is rather larger than that of the magnum, and is nearly as large as its own face of contact with the latter. The magnum has the usual great antero-posterior extension, with elevated posterior convexity applied to the fossa of the lunar. Its posterior process is long, nearly equal to the rest of the bone, and is depressed and flattened distally. The metacarpal facet is very concave. The unciform's anterior or exposed face is a little longer than wide. Its two proximal facets are about equal. It is about as deep as wide, and extends half its length distad to the magnum. Its posterior process is rather narrow; it is narrow and abruptly decurved. Distally, the facet for the fifth metacarpal is well marked, and has about half the area of that for the fourth metacarpal. The functional metacarpals are of moderate length as compared with the elongation of the ulnoradius. The third is largely in contact proximally with the unciform as well as with the magnum. The condyles are stout, and each is laterally impressed by a fossa. The second and fourth have chiefly lateral presentation, but are not much narrower in the shaft than the median metacarpal. The first phalange of the lateral digit is a little shorter than that of the median, while the seconds are of equal length. The extremity of the second digit reaches the proximal third of the length of the median ungual phalange. The fissure of the ungual phalange reaches the middle of its length. The fifth metatarsal is proximally rather stout; but it soon contracts to a thin rounded extremity, at only one-fifth the length of the fourth.

Measurements of Fore Limb.	M.
Antero-posterior diameter of cotyloid cavity of scapula	.015
Diameter of head of humerus { transverse	.020
Diameter of head of humerus { anteroposterior	.019
" with greater tuberosity	.030
Length of humerus on outer side	.110
Diameter humerus at epicondyles { transverse	.021
Diameter humerus at epicondyles { anteroposterior externally	.015
Length of ulna	.165
" radius	.141
Depth of olecranon distally	.015
Width of ulna at coronoid	.015
" " carpal facet (greatest)	.007
" radius at head	.016
" " carpal facets	.014
" " widest point distally	.016
Length of carpus at magnum	.015
" " unciform	.018

Measurements of Fore Limb.	M.
Length of lunar	.010
Depth "	.011
Length of magnum	.005
Depth "	.017
Length unciform	.009
Width "	.009
Depth " (total)	.014
" " of inferior facets	.007
Length of third metacarpal	.068
Proximal diameter third metacarpal { anteroposterior	.008
Proximal diameter third metacarpal { transverse	.008
Length of fifth metacarpal	.012
" median series of phalanges	.027
" first median phalange	.010
Width of do. proximally	.008
Length of second phalange	.006
Widths of median ungual phalange { proximally	.0070
Widths of median ungual phalange { medially	.0055
Widths of median ungual phalange { greatest	.007

The body of this animal was about the size of that of a red fox. The legs were more slender or elevated, and the head of course was shorter and thick.

The unique specimen on which our knowledge of this species rests was cut from a block of calcareous sandstone of the bed of the Washakie basin of the Bridger Epoch, near South Bitter creek, Wyoming Territory. The bones are generally in the relation of the position in which the animal died. The neck is depressed and the left fore leg raised so as to be in contact with it, and the head is raised so as to clear the left wrist.

Triplopus amarorum Cope.

The characters of the fore-foot of this species being unknown, it is not possible to determine its generic position. It has, however, one of the well-marked characteristics of the genus *Triplopus*, in the osseous enclosure of the *meatus auditorius externus*, through the ossification of the external prolongation of the otic bulla, and tympanic cartilage. I cannot therefore refer it to *Hyrachyus*.

It is represented by a skull from which a large part of both maxillary bones and the mandible have been lost, and which is accompanied by parts of the ulna and radius, parts of the ilium, a femur, and tibia, and nearly all of the posterior foot of the right side. The posterior parts of both maxillary bones remain, and they support each, the last superior molar tooth from which the external wall has been broken away. The portions of molars remaining exhibit characters which lead me to suspect that the

species does not belong to *Hyrachyus*. The anterior cross-crest of the molar preserved, is lobate, resembling the same ridge in the species of *Anchitherium*. The posterior cross-crest is uninterrupted. If this species possesses affinity with *Anchitherium*, it will perhaps possess three digits of the manus, in which case it will be referred to the *Triplopidæ*, in harmony with the indication furnished by the ear structure.

The *Triplopus amarorum* is much larger than the *T. cubitalis*, equalling the *Hyracodon nebrascensis*. It differs from the *T. cubitalis* in the stronger temporal ridges, and more elevated sagittal crest; also, in the shorter posttympanic process. The internal lobes of the last superior molar are connected by a basal ledge, not found in the *T. cubitalis*.

The interorbital space is wide and flat, and is most expanded at the postorbital angles.

From this point the face contracts rapidly forwards. From the same angle it contracts abruptly posteriorly to the rather narrow brain-case. The anterior temporal ridges are nearly transverse near the postorbital processes, and then converge more gradually, uniting opposite the posterior inferior border of the zygomatic fossa. The elevated sagittal crest diverges into two lateral supraoccipital crests, which contract as they descend, and continue to the extremities of the posttympanic processes. Although the postorbital angles are prominent, they cannot be called processes. The paroccipital processes are large, and are directed vertically downwards. They are separated by the usual concavity from the occipital condyles. The posttympanics are very short, forming only an angle projecting downwards at the anterior base of the paroccipitals, from which they are only separated by a notch. The inferior side of the tympanic bone is flat near the meatus, but opposite the stylomastoid fossa its posterior border is turned forwards, and is produced into a well marked process. It encloses a groove in front of it, which is continuous with the pterygoid fossa. The petrous bone is not inflated, and its inferior surface is divided into two longitudinal ridges. The inner is the less prominent, and is in close contact with the basioccipital. The postglenoid processes are robust and obtuse. The basioccipital is excavated in front of each of the condyles. The inferior surface is nearly flat, with a slight median keel. The pterygoid fossa is well defined, and is long and narrow. The posterior nareal trough is elongate, the descending pterygoid processes of the sphenoid originating as far back as the apex of the *os petrosum*. This species is especially characterized by the presence of an acute keel-like ridge, which extends horizontally above the foramina sphenoörbitale and opticum, and turns upwards anterior to the latter, terminating a half inch below the inferior base of the postorbital process. All the foramina are below it, but there is a fossa above it, opposite the interspace between the *f. opticum* and *f. sphenoörbitale*.

A supraorbital foramen pierces the frontal bone, a quarter of an inch within the superciliary border. There are five or six postparietal foramina, two of which are nearly on the squamosal suture. There is a postsqua-

mosal foramen, and also a not very small supraglenoid foramen. There is a small foramen anterior to the optic, and in line with the posterior part of the postfrontal angle. The *foramen opticum* is large, and is 10mm. in front of the *f. sphenoörbitale.* The latter is separated by a lamina from the large and vertically oval *f. rotundum.* The latter is joined by the large alisphenoid canal, whose posterior orifice is as large as the foramen ovale. The latter is large, and is well separated from the *f. lacerum anterius.* The *f. f. lacera* are well closed up, the *posterius* being reduced to what is probably the jugular foramen. The *f. condyloideum* is large, and is an anteroposteriorly placed oval. Its anterior extremity is opposite to and well separated from the *f. jugulare.*

The nasal bones are spread out posteriorly, and their posterior extremities are truncate. The coronal suture passes downwards at the narrowest part of the cranium behind the postfrontal angles. The squamosal bone does not reach the frontal. The parietal does not extend so far posteriorly as the lateral occipital crests, except near the squamosal.

The characters of the last superior molars have already been mentioned. The posterior transverse crest is uninterrupted, but the anterior consists of closely united internal and median lobes. The division is marked on the posterior side, and on the edge of the crest; the anterior face is plane. The longitudinal external crest sends a strong protuberance into the head of the valley, which is grooved on its surface. There is a strong anterior basal cingulum which rises to an anterior cusp. On numerous surfaces the enamel is slightly rugose. The inferior canine teeth are in continuous series with the incisors, and are slightly larger than they.

Measurements of Skull.	M.
Length from line connecting anterior borders of orbits to occipital crest	0.132
Length from line connecting posterior borders of orbits to occipital crest	.100
Width between postorbital angles	.100
" " anterior borders of orbits	.076
Elevation of occiput	.065
Width between mastoid ridges	.065
" " *ossa petrosa* at middle	.018
Diameters third superior true molar { anteroposterior	.0200
Diameters third superior true molar { transverse	.0205
Diam. second superior true molar (base) { anteroposterior	.0200
Diam. second superior true molar (base) { transverse	.0150

The portion of ilium remaining exhibits a rather narrow neck and a concave external face. A fragment of the femur shows a prominent third trochanter, with an obtusely rounded apex. The distal part of the fibula is not coössified with the tibia. Its shaft is exceedingly slender. The angles bounding the trochlear grooves and ridges of the tibia are of sub-equal

lengths. The median ridge is rather wide ; the inner malleolus is narrow, has no distal facets and no distinct tendinous grooves externally.

The posterior foot is both relatively and absolutely smaller than that of *Hyrachyus eximius*. The trochlea of the astragalus is narrower and more deeply grooved. The crests are obtuse, and not so narrowed as in *Mesohippus bairdi*, nor are the malleolar facets of the astragalus so sharply defined as in the latter species. The external ligamentous fossa is, however, deep, and is bounded anteriorly by a low trihedral tuberosity not found in the *M. bairdi*. The head of the astragalus is not sessile as in *M. bairdi*, and has rather the proportions of *H. eximius*. The cuboid facet is a bevel of the external side of the distal extremity, as in *H. eximius*, and is not on a produced ledge, as in *M. bairdi*. The internal tuberosity of the head is not as much developed as in either of the species named. The navicular face of the astragalus is horizontally divided by a shallow ligamentous fossa. The calcaneum is much like that of *Hyrachyus eximius*. The cuboid face is less oblique than in that species, in the anteroposterior direction, and is less crescentic in outline than in *M. bairdi*. The sustentaculum is rather more extended transversely than in *H. eximius*, but resembles that species more than the *M. bairdi*, in wanting the deep groove at its base on the inferior side, which cuts it off from the rest of the calcaneum. The remainder of the inferior surface is flat, and not grooved for a tendon as in *H. eximius*.

The remainder of the tarsus includes the usual five bones, the three cuneiforms being present. They are in general a good deal like the corresponding bone of *Hyrachyus eximius*. The navicular differs in having a low transverse ridge on its proximal face, which fits the groove of the astragalus already mentioned. The hook of the cuboid is large. The external (anterior) face of the mesocuneiform has one-third the superficial area of the anterior face of the ectocuneiform. The entocuneiform is rather large, and is flat and subsemicircular. Its position is externo-posterior. The ectocuneiform presents facets to both the second and fourth metatarsals, that with the latter the largest. The distal halves of the metatarsals are lost. At their proximal portions they are of subequal width, as in *Hyrachyus eximius*, but the lateral ones are rather narrower at the middles of the shafts.

Measurements.	M.
Width of distal extremity of tibia	.029
" astragalar face "	.019
Length of inner malleolus	.007
" astragalus on inner side	.030
Depth of trochlea " "	.017
" head " "	.0145
Width of trochlea	.015
" navicular facet	.0195
Length of head from inner crest of trochlea	.005
" calcaneum	.058

Measurements.		M.
Length of free part of calcaneum		.037
Distal depth of the calcaneum		.016
Diameters cuboid face calcaneum	anteroposterior	.0145
	transverse	.0145
Length of navicular		.008
" cuboid		.0145
Transverse proximal width of three metatarsals		.027
Diameters of second metatarsal	anteroposterior	.014
	transverse	.007
Antero-posterior diameter of third metatarsal		.0145
Diameters of fourth metatarsal	anteroposterior	.014
	transverse	.012

This species was obtained in 1873 from the bad lands of South Bitter creek, Wyoming, from the Washakie basin of the Bridger formation. The locality is the same as that which furnished the *Triplopus cubitalis*, the *Achænodon insolens*, etc.

HYRACODONTIDÆ.

This family, which I characterized in 1879, includes, so far as yet known, the single genus *Hyracodon*, which is found in the Oligocene White river formation of North America. According to Marsh, the digits of this genus number three on both anterior and posterior limbs. It has a full series of incisor teeth in both jaws.

RHINOCERIDÆ.

This extensive family has left representatives in all parts of the Northern Hemisphere, and species still exist in the Old World. From the following table the range of variation of its genera can be readily seen :

I. Four anterior digits.

Incisors $\frac{2}{1}$; canine $\frac{0}{1}$; no horn; posttympanic bone distinct. *Aceratherium.*

II. Three anterior digits.

a. Posttympanic process not coössified with postglenoid.

Incisors $\frac{2}{1}$; canines $\frac{0}{1}$; no dermal horn ..... *Cœnopus.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; no dermal horn ..... *Aphelops.*

Incisors $\frac{0}{1}$; canines $\frac{0}{1}$; no dermal horn ..... *Peraceras.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; a tuberosity for a dermal horn on each nasal bone. *Diceratherium.*

Incisors $\frac{1}{1}$; canines $\frac{0}{1}$; a median dermal nasal horn ..... *Ceratorhinus.*

Incisors $\frac{3}{2}$; canines $\frac{0}{1}$ ..... *Zalabis.*

Incisors $\frac{0}{0}$; canines $\frac{0}{0}$; dermal horn median; no osseous nasal septum .... *Atelodus.*

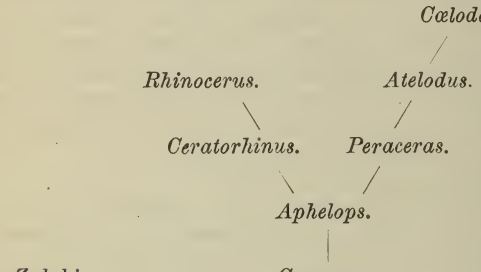
aa. Posttympanic process coösified with postglenoid;

Incisors $\frac{1}{1}$; canine $\frac{0}{1}$; dermal horn median; nasal septum not ossified .... *Rhinocerus.*

Incisors $\frac{0}{0}$; canine $\frac{0}{0}$; dermal horn median; nasal septum ossified ..... *Cœlodonta*

It can readily be seen that the genera above defined form a graduated series, the steps of which are measured principally by successive modifications of four different parts of the skeleton. These are, first, the reduction of the number of the toes of the anterior foot ; second, the reduction in the number and development of the canine and incisor teeth ; third, the degree of closure of the meatus auditorius externus below ; and, fourth, in the development of the dermal horns of the nose and its supports. While these characters have that tangible and measurable quantity which renders them available for generic diagnosis, there are others which possess a similar significance, and which I have noticed in an article published in the bulletin of the U. S. Geological Survey of the Territories for September 1879.

This series may be represented in genealogical relation, as follows :*



The early type, which corresponds most nearly with *Cœnopus*, and which preceded both it and the *Aceratheria* in time, is the genus *Triplopus* Cope, which has left a species in the Upper Bridger of Wyoming. Here the incisors are probably $\frac{3}{3}$ and the canines $\frac{1}{1}$. This formula is that of the Eocene tapirs, where the normal numbers $\frac{3}{3}\,\frac{1}{1}$ prevail. *Triplopus* further differs in the primitive condition of the premolars above, which, as in the *Lophiodontidæ*, differ from the molars in their greater simplicity. Thus it is probable that tapiroids, probably *Lophiodontidæ*, gave origin to the *Rhinocerida*, as Marsh has suggested. And it is further altogether probable that the general type of dentition presented by the *Rhinoceridæ*, *Lophiodontidæ*, etc., which I have named the palæotheriodont, took its origin from the type which is intermediate between it and the bunodont, viz, the symborodont, as I have pointed out in an essay on this subject.

The first appearance of dermal horns was apparently in a pair placed transversely on the nasal bones, in species of Eocene *Lophiodontidæ* of the genus *Colonoceras*. The same character has been observed by Marsh in species of the Lower Miocene, which probably belong to the true *Rhinoceridæ*, and which he has called *Diceratherium*. This genus appears to have terminated the line exhibiting this structure, and the family in North America remained without horn. As we have seen, the types possessing the median horn arose in Europe, in the *Ceratorhinus schleiermacheri* of the Middle Miocene, and still survives.

*See American Naturalist, 1880, p. 611.

It may be observed in conclusion that a successive increase of size in the species of this line has taken place in North America with the advance of geologic time. Thus, their probable ancestors of the genus *Triplopus* were the least of all. The *Cœnopoda* of the White River formation were larger; the oldest *C. mite*, being the smallest. The *Aphelopes* of the Loup River or Upper Miocene formation were all larger, and were nearly equal to the large existing species.

TAPIRIDÆ.

The genera of this family are not numerous as yet. The oldest, *Listriodon*, appears in the Middle Miocene (Gers, France), and *Tapirus* is first found in the Upper Miocene (Epplesheim). The recent species of the family belong to *Tapirus* L., and *Elasmognathus* (Gill). A small species, the *Tapirulus hyracinus* Gerv., is from a bed at Perreal, France, which Pictet has identified with the gypsum of Paris (Oligocene). It is sometimes referred to this family, but is not sufficiently well known to determine its position. In America, *Listriodon*, or a genus which has not yet been distinguished from it, is found in the Miocenes.

The three genera are distinguished as follows:

Three anterior premolars different from fourth premolar and true molars; last inferior molar with heel..... *Listriodon.*

One superior premolar different from true molars; no heel of third inferior molar; nasal septum cartilaginous.... *Tapirus.*

Like *Tapirus*, but nasal septum osseous..... *Elasmognathus.*

CHALICOTHERIIDÆ.

Gill; Cope, American Naturalist, 1881, p. 340.

This family had numerous representatives during Eocene time, and a few species of *Chalicotherium* extended into Miocene time. The boundaries which separate the family from the *Lophiodontidæ* on the one hand and the *Menodontidæ* on the other, are not always easy to determine. From the former the symmetrically developed external Vs of the superior molars, and the double Vs of the inferior molars distinguish it. Yet in *Rhagatherium* the external Vs are not so well distinguished as in other *Chalicotheriidæ;* and in *Propalæotherium*, the anterior cingular cusp produces a part of the assymmetry found in the *Lophiodontidæ*. The character of the double inner cusps of the superior premolars, which distinguish the *Menodontidæ*, is only applicable to the last premolar in *Diplacodon* of the latter, while a trace of the additional cusp of this tooth is found in the Chalicotheroid *Nestoritherium*.

In using the following table it must be borne in mind that the number of the toes has been determined in a very few of the genera. Should any of them prove to have but three digits on the anterior foot, such genera must be referred to a new family intermediate between this one and the *Palæotheriidæ*.

PROC. AMER. PHILOS. SOC. XIX. 108. 2x. PRINTED MAY 16, 1881.

I. Internal cones of superior molars separate from external lobes.

A. Cusps of inferior molars not completely united;

a. External lobes of superior molars more or less conic.

Inferior premolars III and IV compressed, three lobed; a diastema both behind and before P-m. II.....*Rhagatherium*.

AA. Cusps of inferior molars united into two Vs.

a. Incisors present.

β. No diastema in front of second inferior premolar.

Second premolar without inner lobe; last molar with one inner cone.....*Leurocephalus*.

Second premolar with inner cone; last superior molar with an inner cone.....*Palæosyops*.

Second premolar with inner cone; last superior molar with two inner cones.....*Limnohyus*.

ββ. A diastema in front of second inferior premolar.

Two inner cones of last superior molar.....*Lambdotherium*.

aa. Incisors absent from both jaws.

Last superior molar with one internal cone.....*Nestoritherium*.

II. One or both internal cusps of superior molars united with the external lobes by cross-crests.

a. External cusps of superior molars more or less conic;

An anteroexternal cingular cusp.....*Propalæotherium*.

aa. External lobes of superior molars, inflected Vs.

β. No crescentic inner lobes.

No intermediate lobes.....*Chalicotherium*.

ββ. One or more lobes of each molar crescentic.

Intermediate lobes, and one internal cone of superior molars.....*Meniscotherium*.

The following regions have thus far furnished species of the above-mentioned genera:

Europe—*Rhagatherium, Propalæotherium, Chalicotherium*.

N. America—*Leurocephalus, Palæosyops, Limnohyus, Lambdotherium, Meniscotherium*.

Asia—*Nestoritherium*.

Of the American genera, *Leurocephalus* S. S. & O. has been found by the Princeton exploring expedition of 1877 in the Bridger formation, but I have not met with it myself. *Meniscotherium* Cope, is known from a single species found by myself in the Wasatch formation of New Mexico, and described in my report to Capt. G. M. Wheeler (1877).

FIG. 2. Part of right maxillary bone of *Meniscotherium chamense* Cope, from the Wasatch bed of New Mexico. From Report Capt. G. M. Wheeler, IV, ii, Pl. LXVI.

MENODONTIDÆ.

The known genera of this family are not numerous. They are defined as follows:

I. Vs of inferior molars probably incomplete; superior molars with intermediate tubercles.

Internal cusps of superior molars well separated.....*Acoëssus*.

II. Inferior molars with the crowns thrown into two Vs; superior molars without intermediate tubercles.

a. Last superior premolar only with two inner tubercles.

Incisors present.....*Diplacodon*.

aa. All the superior premolars with two interior cusps.

Six inferior incisors, canines very large.....*Dœodon*.

Six inferior incisors; canines very small.....*Menodus*.

No inferior, and four small superior incisors; canine very small.....*Symborodon*.

The first appearance of this family was in the Early Eocene in the genus *Acoëssus* Cope, which was a cotemporary of *Hyracotherium*, and which it resembles in some respects. Its typical species was called *Hyracotherium siderolithicum* by Pictet, its describer, but Kowalewsky has already expressed the opinion that the species does not belong to that genus. It is from the Lower Eocene of Mauremont, Switzerland. The remaining genera are, as yet, American, excepting one, which is represented by an Austrian species, not yet well known. *Diplacodon*, in its simpler premolars, approaches the *Chalicotheriidæ*, and is the oldest of the American genera. It is from the Uinta or Upper Eocene. *Menodus* and *Symborodon*, which include some species of gigantic size, belong in the White river or Oligocene, while *Dœodon* has so far only been obtained from the Truckee or Upper Oligocene.

MACRAUCHENIIDÆ.

But one genus of this family is known at the present time. The following are the dental characters of *Macrauchenia*. Formula: I. $\frac{3}{3}$; C. $\frac{1}{1}$; P.m. $\frac{4}{4}$; M. $\frac{3}{3}$, forming an uninterrupted series. The superior molars present two external Vs, and two oblique transverse crests, somewhat as in *Palæotherium*. The spinous foramina pierce the neural arch of the dorsal vertebræ (Gervais). There is no intertrochlear crest of the humerus, but the carpal facets of the radius are well distinguished. The internal malleolus is small, but the fibular malleolus is coössified with the tibia at an early age, and articulates with the calcaneum. The trochlea of the astralagus is well developed. The lateral digits are large, and the distal keels of the metapodials are continued on the anterior face of the condyle.

The position indicated by the above characters is a remarkable one. The uninterrupted dental series and the absence of intertrochlear humeral crest, are primitive features among ungulate *Mammalia*. The radiocarpal articulation is facetted as in higher ungulates, but lacks the inferior condyloid face of those types. The completeness of the metapodial distal keels is a feature of high specialization, only seen in the *Equidæ* of this order. The coössification of the external malleolus is also a character peculiar to the *Equidæ* among the *Perissodactyla*. There are two other characters which are not elsewhere found in this order, viz: the articulation of the fibula with the calcaneum, and the absence of the vertebrarterial canal. The former belongs to the *Artiodactyla* generally, and to the Proboscidæ, and the latter to the ruminant family of the *Camelidæ*. Thus the *Macrauchenidæ* stand out as one of the most distinct of the families of the *Perissodactyla*, and one to which we may anticipate considerable accessions in future.

But two species of *Macrauchenia* are known, a larger, *M. patachonica*, and a smaller, *M. baliviensis*, both from the Pliocene formation of South America.

PALÆOTHERIIDÆ.

This family has been already defined on page 378. In its complex premolar teeth, which in the upper jaw resemble the molars in composition, it shows an advance over the *Chalicotheroid* and other genera of the Lower Eocene. In fact, it has not been found in the Lower Eocene, but commences in the Upper Eocene in the genera *Palæotherium* and *Paloplotherium*. Thence it extends to the very summit of the Miocene, and may even occur in the European Pliocene (*Protohippus*). Its members exhibit considerable range of variation in the details of the teeth and feet, but no striking break of family importance occurs. The most noteworthy interruption is that which is found between the *Palæotherinæ* and *Hippotheriinæ*, where there is a change in the form of the proximal extremity of the humerus from a tapiroid to a horse-like form, and a modification of similar significance in the molar teeth, by the addition of a deposit of cementum.

The characters of the genera are as follows :

I. *Palæotheriinæ*. Bicipital groove of humerus simple ; teeth without cementum.

a. One or more internal tubercles of superior molars distinct.

External Vs of superior molars not well distinguished externally..... *Anchilophus.*

External Vs separated by a vertical rib ; intermediate tubercles not connecting fore and aft..... *Paloplotherium.*

External Vs separated ; intermediate tubercles extended fore and aft..... *Anchippus.*

aa. Internal tubercles of superior true molars continuous with the transverse ridges.

Inferior molars with two Vs only; lateral toes large..... *Palæotherium.*

Inferior molars with distinct internal tubercles ; lateral toes small ; a short fifth metacarpal..... *Mesohippus.*

Inferior molars with cusps at the inner extremities of the Vs ; lateral toes small; no fifth metacarpal..... *Anchitherium,*

II. *Hippotheriinæ*. Bicipital grooove of humerus double; molars with cement in the valleys. (Intermediate tubercles connected fore and aft.)

a. One or more internal tubercles of superior molars distinct.

Inner lobes of inferior molars enlarged..... *Hippotherium.*

aa. Internal tubercles of molars not distinct.

Inner lobes of inferior molars enlarged..... *Protohippus.*

The genera of this family are generally of less antiquity than those of the *Chalicotheriidæ*, and they range from the Middle Eocene to the Pliocene. *Paloplotherium* is found in the Middle Eocene, and is, as might have been anticipated, more nearly allied to the *Chalicotheriidæ* than any other genus of this family. *Propalæotherium* is not far removed from it. *Anchilophus* is upper Eocene, and is allied to the genus just named, and also to *Pachynolophus* among the *Lophiodontidæ*. These early genera constitute by their similarity, the bond of connection between the three families which in their later and specialized forms are very different from each other. *Palæotherium* is chiefly found in the Upper Eocene, and *Mesohippus* is only known from the White river or Oligocene, an age between Eocene and Miocene. *Anchitherium* commences in the Middle Miocene and has *Anchippus* for a cotemporary. *Hippotherium* existed only in the latter part of the Miocene Epoch, consistently with the greatly specialized structure of its limbs and teeth, and the nearly allied *Protohippus* lived with it; while in Europe a species with the same type of molar teeth is found in the Pliocene epoch (Forsyth-Major). These forms were cotemporary with the *Equidæ*, which outlived them. They have many points of resemblance to that family, but nevertheless remain at a considerable interval from them in the structure of the feet.

The geographical distribution of these genera, so far as present knowledge shows, is as follows:

North America alone—*Mesohippus, Anchippus.*
North America and Europe—*Anchitherium, Hippotherium, Protohippus.*
Europe only—*Anchilophus, Paloplotherium, Palæotherium.*

EQUIDÆ.

The two genera of this family are distinguished as follows:

Internal lobes of superior molars subequal.....*Hippidium.*
Anterior internal lobes of superior molars much larger than the posterior.....*Equus.*

The genus *Hippidium* is extinct, and its species have been thus far found only in North and South America, in beds of Pliocene age. *Equus* made its appearance during the same period, and is represented by several existing species.

Besides the reduction in the number of digits, which is carried farther here than in any other family of *Mammalia*, there are several other characteristics of specialization. Thus in the dentition, the spaces between the tubercles are filled with cementum. These valleys are generally deep, owing to the prismatic forms of the molars. The cups of the incisors are completely developed, and also filled with cementum. There are two bicipital grooves of the humerus. The preceding characters are also found in the *Hippotheriinæ* of the *Palæotheriidæ.*

The *Equidæ* adds another evidence of greater specialization than the latter group in the structure of its feet, *i. e.*, the distal metapodial keels are completed forwards, as in most ruminants.

The similarity of the modifications which have supervened on the Artiodactyle and Perissodactyle lines in attaining their most specialized extreme has often been noticed. I repeat them here in tabular form in three columns. These show (Table I) the modifications in which the *Equidæ* and *Bovidæ* are identical or nearly so, which place them at the heads of their respective orders; Table II, those in which the *Equidæ* are the more specialized of the two; and Table III, those in which the *Bovidæ* displays the highest differentiation.

	Table I.	Table II.	Table III.
1	Obliteration of first premolars.	Cupping of incisor teeth.	Absence of superior incisors.
2	Selenodont and prismatic character of molars.	Deposit of cementum in teeth	Trough-shape of odontoid.
3	Flattened odontoid process.	Double bicipital groove of humerus.	Greater involution of lumbar prezygapophysis.
4	Reduction and coössification of ulna.	Reduction of metapodials to one.	Fibular articulation of calcaneum.
5	Intertrochlear crest of humerus.		Distal ginglymus of astragalus.
6	Distal facets of radius.		
7	Involution of lumbar prezygapophyses.		
8	Elongate sacrum.		
9	Shaft of fibula atrophied, and its distal extremity coössified to tibia.		
10	Reduction in number of digits.		
11	Anterior extension of carinæ of metapodial bones.		

Note on the Structure of the Posterior Foot of Toxodon. By E. D. Cope.

The position of the genus *Toxodon* in the system of Mammalia, is a question upon which few authorities have expressed positive opinions, and which is generally regarded as still an open question. In the lack of certainty on the subject, a separate order, the "*Toxodontia*," has been proposed for its reception. It is known that the genus is ungulate, but the opinions of authors are much divided as to its relations to the three principal orders included under that head. Resemblances to the *Proboscidea* have been detected, but Professor Gervais (Comptes Rendus, 1878), asserts that there is a close resemblance to the genus *Hippopotamus* in the structure of the posterior foot.

Having come into possession of remains of *Toxodon*, which include the greater part of the skeleton, I make a few observations on the affinities suggested by the posterior foot, the only portion just now accessible in my collection. The calcaneum and astragalus have been more or less imperfectly figured by De Blainville and Burmeister, but no one has, to my knowledge, represented the entire foot. The calcaneum is rather short and stout, and its external convex tuberosity is of unusual size. Its articular surface is divided into two subequal parts, the internal of which supports the astragalus, the external the fibula. Thus the fibular articulation is of unusual size. The cuboid facet is on the inferior face of the extremity of the calcaneum, thus looking directly downwards when the bone is prone. In order to articulate with the remainder of the foot, the calcaneum must have been inclined upwards and forwards at an angle of 45°, and the cuboid inclined downwards and forwards at a similar angle. That the axis of the astragalus had the latter inclination is proven by the fact that the superior plane of the sustentaculum lies at that angle to the axis of the remainder of the calcaneum. The great convexity of the external tuberosity for the astragalus will also permit of such a position for the astralagus. The navicular facet of the astragalus is plane and truncates the bone somewhat inferiorly as well as distally, so as to present in the same way as the cuboid. There is probably no cuboid facet. I have not seen the cuneiform bones. The metatarsals and phalanges are robust and rather short. The distal keels of the former are posterior and rudimental. Their proximal extremities have a small lateral tarsal facet as well as the principal one. The median digits are of unequal length, and the lateral ones are much shorter, but robust. Whether there are four or five digits I cannot definitely ascertain.

The above characteristics are very significant. They at once refute any supposition of affinity to the *Artiodactyla*, whether suilline or ruminant. The form of the astragalus and wide fibular condyle of the calcaneum, opposes the reference of the genus to the *Perissodactyla*. On the other hand, all the characters of the feet thus far adduced, are found in the *Proboscidea*. They are not only those of that order, but they are carried to a degree of exaggeration, as though *Toxodon* represented a high grade of

specialization of that order. The posterior feet were more truly plantigrade for the extremity of the calcaneum reached the ground, while the instep was elevated above it, being supported, no doubt, by a more or less elastic pad. This arched or angulate plantigrade type of foot, has a remote parallel in that of man. It is quite unique among ungulate *Mammalia*.

What difficulties the other parts of the skeleton may present, I do not yet know, but I perceive nothing in the dentition which forbids the reference of *Toxodon* to the *Proboscidia*. The dentition is scarcely more different from that of *Mastodon* or *Dinotherium*, than that of *Bos* is from *Dicotyles* or *Hippopotamus*. The former genera may be the extremities of a series whose intermediate members are as yet undiscovered. In the latter case, the intermediate forms are mostly known.

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(18)

ON THE

FORAMINA PERFORATING THE POSTERIOR PART

OF THE

SQUAMOSAL BONE OF THE MAMMALIA.

By E. D. COPE.

(*Read before the American Philosophical Society, Feb. 6, 1880*).

Compliments of
The Author

On the Foramina Perforating the Posterior Part of the Squamosal Bone of the Mammalia. By E. D. Cope.

(*Read before the American Philosophical Society, February* 6, 1880.)

The number of perforations of the posterior part of the squamosal bone in the *Mammalia* is considerable, and they have not attracted that attention from anatomists which their importance deserves. As I have found them to be especially valuable in diagnosis, I have thought it might be useful to place on record the manner of their occurrence in various recent genera with whose structure we are more or less familiar in other respects.

The one of these foramina of which some notice has been taken, is the *postglenoid*, which is mentioned by Flower (Osteology of Mammalia) as occurring in the dog and bear, and as absent in the cat. I find five other foramina which usually form the outlets of canals which are connected with the lateral venous sinus. The principal canal extends from the postglenoid foramen upwards and backwards between the os petrosum and the squamosal, and enters the cranial cavity at the superior border of the former. At a point in the parietal bone, often on or very near the squamoso-parietal suture, it issues on the surface again, in the foramen which may be called the *postparietal*. A branch of the canal may take a posterior direction and issue on the occipital face of the skull in the suture between the *ossa petrosum* and *exoccipitale*, forming the *mastoid* foramen. Or a posterior branch may issue in the posterior part of the squamosal bone in a lateral foramen, the *postsquamosal*. In certain Mammals a large foramen perforates the base of the zygomatic process of the squamosal from above, entering the canal after a short course of its own; this I call the *supraglenoid* foramen. Still another inlet to the canal is found in some Mammals, perforating the squamosal below the crest which connects the zygoma with the inion, occupying a position posterior and exterior to the post-

glenoid, and generally looking more downwards than outwards. I call this the *subsquamosal*. These foramina may be arranged in four sets, as follows :

I. Looking downwards ;
  Postglenoid.
  Subsquamosal.
II. Looking outwards ;
  Postsquamosal.
  Postparietal.
III. Looking upwards ;
  Supraglenoid.
IV. Looking backwards ;
  Mastoid.

Some foramina of the same region are not necessarily connected with the *sinus lateralis*. Hyrtl, in his essay* on the arterial system of the *Edentata*, shows that a foramen near to the postsquamosal of the *Tamandua tetradactyla*, gives passage to an "*arteria diploëtica*," which is formed by the junction of the occipital branch of the carotid with an ascending branch of the *temporo-maxillaris* division of the carotid. The *a. diploëtica* issues in a foramen which perforates the parietal bone on the orbital border. These two foramina may be called the *f. diploëticum posterior* and *f. d. anterior*, respectively. The former enters from the fundus of the same small fossa, which is also perforated in its superior portion by the *f. postsquamosate*, the canal from the latter foramen taking the usual vertical direction.

Still another foramen exists, which is, so far as my present knowledge goes, confined to the *Monotremata* and *Marsupialia*. It enters the posterior base of the zygomatic portion of the squamosal, and is directed forwards.

In *Tachyglossus* it passes through the base of the zygoma, issuing in the base of the zygomatic fossa. In the *Marsupialia* it enters a fossa of the squamosal bone, which may or may not be partially filled with cancellous tissue. I call this the *foramen postzygomaticum*.

I now give the results of my observations on the crania of the most important genera which I have observed, one hundred and sixteen in number.†

Monotremata.

Tachyglossus. The only foramina are the *f.f. diploëtica anterior* and *posterior*, and the *postzygomaticum*. The anterior half of the canal connecting the former two has no external wall.

Ornithorhynchus. Postzygomatic large and passing through the zygoma ; postsquamosal large ; no other foramina.

Marsupialia.

The types of this order generally have the postglenoid, and hardly ever have the supraglenoid or postparietal. They are generally distinguished

* Denkschriften Wiener Akademie, 1854, T. III, pl. 1.

† Most of these are preserved in my private collection ; for a few I am indebted to the Museum of the Philadelphia Academy.

by the presence of the subsquamosal, but in *Hypsiprymnus* and *Macropus* this foramen becomes the postsquamosal, through the failure of the postzygomatic crest. It need not be confounded with another foramen also found in these genera, which enters above the *meatus auditorius externus*, and communicates with the tympanic chamber, and which I call the *supratympanic foramen*. The subsquamosal enters the sinous canal, and in *Phascolarctos*, where the postglenoid is wanting, constitutes its only external outlet. The order is further characterized by the presence of the postzygomatic foramen.

Phascolomys ; postzygomatic chamber enormous, extending above meatus. No foramina below, except supratympanic ; above, a supraglenoid and one or two postglenoids.

Phascolarctos ; subsquamosal and postzygomatic only ; the latter communicating with an empty chamber.

Macropus and *Hypsiprymnus ;* postglenoid, postzygomatic, supratympanic and postsquamosal ; the second communicating with a chamber filled with cancelli.

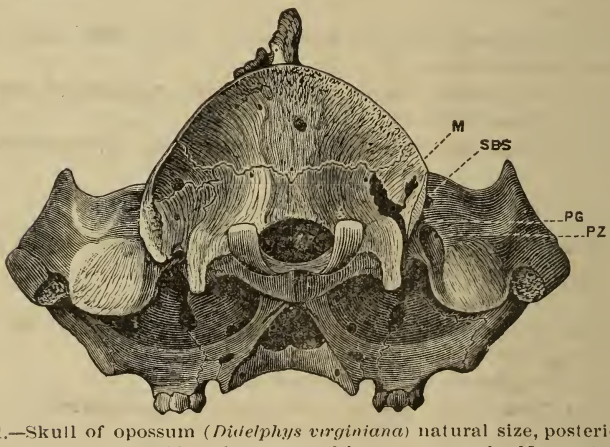

FIG. 1.—Skull of opossum (*Didelphys virginiana*) natural size, posterior view, parts of the right mastoid and squamosal bones removed. M, mastoid foramen; SBS, subsquamosal; PG, postglenoid; PZ, postzygomatic foramen.

Didelphys ; postglenoid, postzygomatic, subsquamosal and mastoid ; postzygomatic small.

Dasyurus ; postglenoid, subsquamosal and probably mastoid. I cannot find a postzygomatic.

Phalangista ; postsquamosal and postparietal only ; no postzygomatic nor supratympanic.

EDENTATA.

Tamandua ; F. f. diploëtica anterior and *posterior*, and postsquamosal only.

Dasypus (6-*cinctus*) ; postglenoid (large), postsquamosal, mastoid, several postparietals, and a small subsquamosal.

Chlamydophorus; a postglenoid only.

Manis; postzygomatic only.

Megalonyx; postsquamosal and supratympanic; a closed fissure at position of postglenoid. A large foramen below the usual position of mastoid.

Bradypus and *Cholœpus;* no foramina.

Rodentia.

In this order, so far as yet observed, the supraglenoid and postparietal foramina are never present, while the mastoid is rarely, and the subsquamosal is generally, represented. The ridge connecting the zygoma with the inion being weak, the difference between this foramen and the postsquamosal is less marked in this order than in the *Marsupialia*. It is, however, always on the inferior border of the squamosal bone.

Lepus and *Lagomys;* no foramina.

Lagidium; no foramina.

Cercolabes; no foramina.

Lagostomus, Geomys and *Erithizon;* an enormous postglenoid without internal canal.

Capromys, Cœlogenys, Sciurus, Haplodontia, Hesperomys, Mus; postglenoid and postsquamosal only.

Hystrix, Hydrochœrus, Neotoma and *Arvicola;* postglenoid and postsquamosal foramina confluent; no others.

Castor, Cynomys and *Spermophilus;* postglenoid, postsquamosal and mastoid.

Insectivora.

The foramina are very much as in the *Rodentia* in the smaller forms, and as in the *Carnivora* in the larger.

Blarina, Condylura and *Scalops;* postsquamosal only.

Erinaceus; postglenoid and postsquamosal only. *Mystomys* the same, according to Allman's figures.

Centetes; postglenoid, postparietal and mastoid.

Solenodon (from Peters' figures); postglenoid and postparietal.

Chiroptera.

In some members of this order the foramina are, as in many Carnivora, limited to the postglenoid and postparietal.

Scotophilus (*fuscus*); postglenoid, postparietal and mastoid.

Pteropus; postglenoid, subsquamosal and postsquamosal.

Carnivora.

In this order the foramina are few in number, and are very well defined. None of them possess more than three, while the specialized forms, both terrestrial and aquatic, do not possess them.

Trichecus and *Arctocephalus;* no foramina.

Phoca; a rudimental postglenoid.

Ursus, Arctotherium and *Hyænodon;* postglenoid, mastoid and postparietal.

Enhydrocyon and *Temnocyon;* postglenoid and postparietal only.

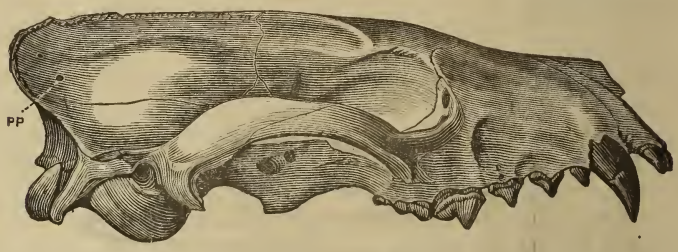

FIG. 2.—*Temnocyon coryphæus* Cope, Lower Miocene of Oregon; one-half natural size. PP, postparietal foramen.

Archælurus, Dinictis, Pogonodon, Hoplophoneus and *Machærodus* (*cerebralis*); postglenoid and postparietal only.

Procyon, Nasua and *Bassaris;* postglenoid only.

Canis, Vulpes and *Urocyon;* postglenoid only.

Viverra, Mustela, Putorius and *Mephitis;* postglenoid only.

Felis (*domestica*); sometimes a minute postglenoid only; sometimes none.

Hyæna, Uncia, Cynælurus; no foramina.

PROSIMIÆ.

Lemur, Chirogaleus and *Tarsius;* a postglenoid only.

QUADRUMANA.

Hapale; postglenoid and postsquamosal.

Cebus; postglenoid and postparietal. The latter is on the suture of the parietal and squamosal bones; in *Hapale penicillata* it is entirely within the squamosal bones.

Ateles, Callithrix, Mycetes, Semnopithecus and *Cynocephalus;* no foramina.

Macacus; a small postglenoid.

Troglodytes niger, gorilla; a closed fissure, but no foramen postglenoideum.

Homo; no foramina in sixteen North American Indians examined of the Klamath, Bannock, Crow, Sioux and Cheyenne tribes. One postglenoid on one side in a South Australian. One or two mastoids are more usual, being found in a good many specimens of all races. They are rarest in Hottentot negroes.

CETACEA.

Balæna, Beluga and *Monodon;* no foramina.

SIRENIA.

Halicore and *Manatus;* a huge mastoid only.

HYRACOIDEA.

Hyrax; no foramina.

PROBOSCIDIA.

Elephas; no foramina.

PERISSODACTYLA.

In this order the number of the foramina ranges from very few to many.

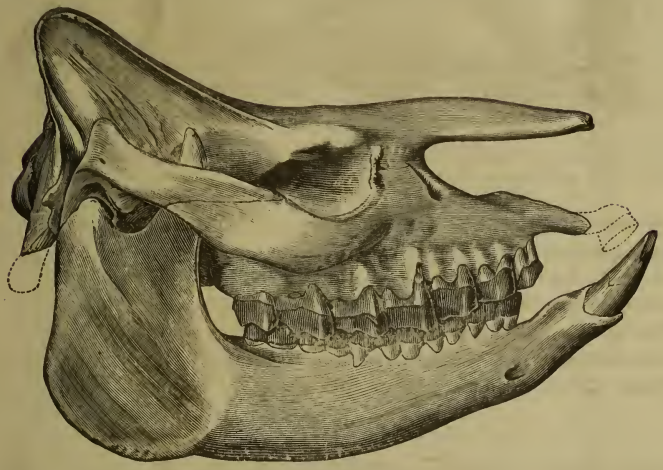

FIG. 3.—*Aphelops megalodus* Cope, Loup Fork of Colorado; one-sixth natural size; showing postparietal foramen.

Rhinocerus, Aphelops; postparietal only.

FIG. 4.

FIG. 5.

Skulls of *Aphelops megalodus* (Fig. 4) and *A. fossiger* (Fig. 5) from behind; one-sixth natural size; showing absence of mastoid foramen.

Tapirus; postparietal and a huge mastoid.

Anchitherium, Hippotherium, Protohippus and *Equus;* postparietal, postsquamosal, postglenoid and supraglenoid. In the last three genera

the vessel issuing from the postsquamosal, grooves the petrous bone, leaving it at a point near that usually occupied by the mastoid foramen. In the second and last genera, and probably in the third, the sinous canal is protected by a bony crest in front, throughout its entire length.

Artiodactyla.

Great diversities are found in this order, especially between the suilline and ruminant divisions. In the former, with the exception of the *Hippopotamidæ*, there are no foramina; in the *Ruminantia* they are more numerous than in any other order of the class. The *Ruminantia* are, like the equine *Perissodactyla*, characterized by the presence of the supraglenoid foramen; to this the *Camelidæ* and some others add the mastoid. The *Tragulina* must be excepted from this rule, for they have nothing but the postglenoid.

Omnivora.

Sus, *Dicotyles* and *Phacochœrus;* no foramina.

Hippopotamus and *Chœropsis;* postglenoid, postsquamosal, mastoid and a rudimental supraglenoid.

Ruminantia.

Tragulus; postglenoid only.

Oreodon; postparietal and mastoid. In one specimen of *O. culbertsoni* from Colorado, I find a minute supraglenoid on each side; in other specimens it is wanting.

Poëbrotherium; postparietal, postglenoid; mastoid; a small supraglenoid.

Fig. 6.—Skull of *Procamelus occidentalis* Leidy, Loup Fork of New Mexico; one-fourth natural size; showing supraglenoid foramen, SPG.

Procamelus, *Camelus*, *Auchenia;* postglenoid, supraglenoid and mastoid.

Bos; postglenoid and supraglenoid only.

Antilocapra; postparietal, postglenoid, mastoid, and a large supraglenoid.

Giraffa; postglenoid, supraglenoid, postsquamosal and mastoid.

Oreas, *Ovis*, *Cervus;* postglenoid, supraglenoid, postsquamosal, postparietal and mastoid.

From the preceding the following conclusions may be derived :

(1) The sinous foramina furnish valuable diagnostic characters, and may, with proper limitation, be used in systematic definition.

(2) The primitive condition of the various mammalian orders appears to have been the possession of a limited number of these foramina.

(3) The monotreme-marsupial line have developed a number of foramina in their own special way.

(4) The *Rodentia* have chiefly developed those of the inferior part of the squamosal bone, if any.

(5) The *Carnivora* commenced with but few foramina, and have obliterated these on attaining their highest development.

(6) The history of the *Quadrumana* is identical with that of the *Carnivora*.

(7) The *Perissodactyla* present very few foramina in the lowest forms, and did not increase them in the line of the *Rhinocerilæ*. In the line of the horses an increase in their number appeared early in geologic time, and is fully maintained in the existing species.

(8) In the Omnivorous division of the *Artiodactyla*, time has obliterated all the sinous foramina. In the Camels an increased number was apparent at the same geologic period as in the history of the horses (White River or Lowest Miocene), and has been maintained ever since ; while the existing *Pecora* present a larger number of the foramina than any of the class of *Mammalia*.

The only relation between these structures and the habits of the species concerned that can now be traced is, that the largest number of the foramina is found in the specialized vegetable feeders, while the smallest number is found in omnivorous forms.

I now give a synopsis of the distribution of the sinous foramina according to the foramina themselves. The *f. f. diploëtica*, *postzygomatica* and *supratympanicum* are not included, as their existence is restricted to the few types already mentioned.

I. No foramina.
Homo, Troglodytes, Cynocephalus, Semnopithecus, Mycetes, Callithrix, Ateles.
Uncia, Hyæna, Arctocephalus, Trichecus.
Elephas, Hyrax ;
Sus, Phacochœrus, Dicotyles.
Lepus, Lagidium, Cercolabes.
Cholœpus, Bradypus.

II. Postglenoid only.

a. Rudimental.
Felis ; Phoca.

aa. Developed.
Chlamydophorus.
Lemur, Chirogaleus, Tarsius ;
Macacus.

Mustela, Putorius, Mephitis; Canis. Vulpes, Urocyon; Viverra. Procyon, Nasua, Bassaris.
Tragulus.

aaa. Enormous.
Lagostomus and *Geomys.*

III. Subsquamosal only.
Phascolarctos.

IV. Postsquamosal only.
Ornithorhyncus, Tamandua, Blarina, Condylura, Scalops.

V. Postparietal only.
Rhinocerus, Aphelops.

VI. Mastoid only.
Halicore, Manatus.

VII. Postglenoid and subsquamosal only.
Hystrix, Hydrochœrus, Capromys, Cœlogenys, Sciurus, Haplodontia, Neotoma, Hesperomys, Mus, Arvicola.

VIII. Postglenoid and postsquamosal only.
Erinaceus.
Macropus, Hypsiprymnus.
Hapale.

IX. Postglenoid and postparietal.
Chiroptera sp.
Temnocyon, Enhydrocyon;
Archælurus, Dinictis, Pogonodon, Hoplophoneus, Machærodus.
Cebus.

X. Mastoid and postparietal.

a. Mastoid small.
Oreodon.

aa. Mastoid enormous.
Tapirus.

XI. Mastoid, postglenoid and postsquamosal.
Castor, Cynomys, Spermophilus.

XII. Mastoid, postglenoid and subsquamosal.
Dasyurus, Didelphys.

XIII. Mastoid, postglenoid and postparietal.
Scotophilus (*fuscus*).
Centetes.
Hyænodon. Ursus, Arctotherium;

XIV. Supraglenoid and postsquamosal only.
Phascolomys.

XV. Supraglenoid and postglenoid only.
Bos.

XVI. Supraglenoid, postglenoid and mastoid.
Procamelus, Camelus, Auchenia.

XVII. Supraglenoid, postglenoid, mastoid, postparietal.

a. Supraglenoid small.
Poëbrotherium.

aa. Supraglenoid large.
Antilocapra.

XVIII. Supraglenoid, postglenoid, mastoid and postsquamosal.

a. Supraglenoid small.
Hippopotamus, Chœropsis.

aa. Supraglenoid large.
Giraffa.

XIX. Supraglenoid, postglenoid, postparietal and postsquamosal.

a. Supraglenoid small; mastoid not grooved.
Anchitherium.

β. Supraglenoid large, mastoid grooved.
Hippotherium, Protohippus, Equus.

XX. Supraglenoid, postglenoid, postparietal, postsquamosal and mastoid.
Cervus, Oreas, Ovis.

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AUTHOR'S EDITION

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY.
F. V. HAYDEN, U. S. Geologist-in Charge.

I.—The Relations of the HORIZONS OF EXTINCT VERTEBRATA OF EUROPE AND NORTH AMERICA.

II.—Observations on the FAUNÆ OF THE MIOCENE TERTIARIES OF OREGON.

BY

E. D. COPE.

EXTRACTED FROM THE BULLETIN OF THE SURVEY, VOL. V, No. 1.

WASHINGTON, February 28, 1879.

Art. II.—The Relations of the Horizons of Extinct Vertebrata of Europe and North America.

By E. D. Cope.

The history of the succession of life upon any one portion of the earth's surface is replete with matter for speculation. It shows us a series of faunæ succeeding each other, each of which, in many instances, commences without previous announcement in the forms of older periods, and disappears without leaving representatives in later ones. With this basis of fact, which naturally enough has been furnished by the longest explored and best known portion of the earth, Europe, we turn to other lands with the hope of obtaining further light upon a subject so full of mystery. These types of life, did they originate in a single centre, from which they disseminated themselves? and, if so, did each form originate in a region of its own or not? Or, did the same types of generic structure appear at different points on the earth's surface independently; and, if so, whether cotemporaneously, or at different times?

For a solution of these and similar questions, we naturally look to a comparison of the facts first established, with those obtained more recently by exploration in other regions. In this quest, no portion of the earth offers greater promise of results than America. As the second great continent, separated from the other by the greatest possible water surface, we anticipate the widest diversity in the character of its life-history. If the types of life have originated independently, we will find evidence of it by studying American palæontology; if their origin has been through gradual modification, America should furnish us with many intermediate faunæ.

The identification of the generic types of North American *Vertebrata* has now advanced to a point which renders such a comparison possible. Although the subject is in its infancy, the following pages will show that an important contribution to it can be now made. The comparisons instituted in this paper commence with the coal-measures, and with the *Batrachia* of that period. As regards the palæozoic fishes, I have not yet devoted that attention to them which is necessary for their discussion, and I refer to the papers of Newberry for several important identifications of genera as common to the two continents.

The structure of the *Batrachia* of the coal-measures is not yet sufficiently well known to enable the most exact comparisons to be made, but close parallels, if not identities, of genera exist. Such are the

Oëstocephalus and *Ceraterpeton* of Ohio as compared with the *Urocordylus* and *Ceraterpeton* of Great Britain.

The Permian vertebrate fauna which I discovered in Illinois and Texas, exhibits close parallels, but not yet generic identity, in the two continents. Thus, the American *Clepsydrops* and *Dimetrodon* are near to the *Deuterosaurus* of Perm in Russia, and the *Lycosaurus* of the mountains of South Africa. The Texan genus *Pariotichus* may, with further information, prove to be identical with *Procolophon* Ow. from the Tafelberg. Humeri of the type discovered by Kutorga in Russia, and by Owen in South Africa, are found in North America, and the same remarkable type has been recently discovered by Gaudry in France. The peculiar type of Labyrinthodont vertebræ described by me under the genus *Rhachitomus* from Texas has been discovered by Gaudry in France. The present indications are that close similarity between the faunæ of this period in Europe and America will be discovered. Nevertheless, up to the present time no representatives of the striking American forms *Diadectes*, *Bolosaurus*, *Empedocles*, and *Cricotus* have yet been found in any other continent.

As regards the Triassic fauna, it differs from that of the Permian in being better known in Europe than America. As marine Trias is little developed in North America, so the vertebrate fauna of the Muschelkalk has not been discovered in the latter country. It is otherwise with the Keuper. The characteristic genus of that epoch, *Belodon*, existed in America, and parallels, if not identity, exist in the genera *Thecodontosaurus* and *Palæosaurus*. These are known in America from teeth only. The reptiles are accompanied in North America, as in Europe, by Stegocephalous *Batrachia*, mostly Labyrinthodonts, but their generic affinities are yet unknown.

The great Jurassic faunæ are as yet but sparsely represented in North American palæontology. The marine *Vertebrata* of the Lias are either unknown or are represented by a few provisional identifications of unsatisfactory fragments. We do not yet know any deposits in North America which contain the typical reptilian genera *Plesiosaurus*, *Ichthyosaurus*, *Pliosaurus*, and *Dimorphodon*, or the fishes of the *Dapediidæ*. This formation, so important in Europe, is almost omitted from the North American series. A few more characteristic fossils of the Rocky Mountain region represent the Oölite, particularly the Upper Oölite, while *Teleosaurus* and *Stenosaurus*, and their allies, are not yet known from North American beds. Strata said to be included in the Dakota (which on the evidence of plants and invertebrate fossils has been placed at the bottom of the Cretaceous series) have produced a genus not yet distinguishable from *Megalosaurus*. This genus has not been identified beyond doubt from above the Oölite in England. From the same beds in the Rocky Mountain region come genera which nearly resemble the one from the English Oölite (Forest Marble) called by Phillips, *Cetiosaurus*, and the genus from the Oxfordian of Honfleur, called by von Meyer,

Streptospondylus. Beyond this no comparisons can be made, and we therefore pass to the rich fauna of the Kimmeridge. North America cannot show such records of this epoch as have been found in Europe. There are no *Archæopteryx*, *Rhamphorhynchus*, nor *Pterodactylus;* no *Leptolepis*, *Thrissops*, nor other of the numerous fishes of Solenhofen. The *Omosaurus* has, however, some very close relatives in the supposed Dakota beds of the Rocky Mountains. No remains of that primitive Marsupial fauna which occurs in the Purbeck have yet been detected in the Western Continent. A partial representation of the Wealden fauna of Europe is found in the beds of the Rocky Mountains mingled with the types of the Oölite and Kimmeridge already mentioned. The relationships of this fauna to those of the European Jurassic series may be thus exhibited:

American.	European.
CAMARASAURUS BEDS.	WEALDEN.
?	*Iguanodon.*
? Hypsilophodon.	*Hypsilophodon.*
	Hylæosaurus.
? Cetiosaurus.	*Cetiosaurus.*
Camarasaurus.	*Eucamerotus.**
	Ornithopsis.
Amphicœlias.	
? Goniopholis.	*Goniopholis.*
	KIMMERIDGE.
Hypsirhophus.	*Omosaurus.*
Caulodon.	*? Caulodon.*†
	OXFORD.
Epanterias.	*Streptospondylus.*
	OÖLITE
	"Cetiosaurus."
? Megalosaurus.	*Megalosaurus.*

From the above table it will be seen how difficult it is at the present to parallelize the related beds of the Jurassic periods of the two continents at the present time. All that can be said is that many types resembling‡ nearly those of different horizons of the European Jurassic are found to have lived together or near together in the Rocky Mountain region of North America.

That the Cretaceous fauna of North America was the richest in the cold-blooded *Vertebrata* is indicated by the present state of discovery. The ocean of the interior of the continent deepened from the beginning

* *Chondrosteosaurus* Owen.

† *Iguanodon præcursor* Sauv.

‡ A near affinity has been shown by Professor Owen to exist between *Eucamerotus* and *Camarasaurus*. Professor Owen believes these genera to be identical; but the neural spines of the anterior dorsal vertebræ are very different, being single in the former, and double in the latter.

of the period until the epoch of the Niobrara, and then gradually shallowed until the elevations of the bottom began to divide the waters. The closing scenes of this great period were enacted amid a labyrinth of lagoons and lakes of brackish and fresh water, whose deposits form the beds of the Laramie epoch.

The fauna of the deep-sea epoch, the Niobrara, is the best known. Here the remains of *Pythonomorpha* constitute its prevailing characteristic, while *Elasmosaurus* and *Polycotylus*, with but few species, represent the numerous *Sauropterygia* of Europe. Crocodiles were apparently wanting, while turtles and a peculiar group of *Pterosauria* were only moderately abundant. The fish fauna was very rich and varied. Here the *Saurodontidæ*, like the Molluscous family of the *Rudistes*, appeared, and as soon disappeared, accompanied by the peculiar form, *Erisichthe*, and the family of *Stratodontidæ*. The genera of Mount Lebanon, *Leptotrachelus* and *Spaniodon*, occur in this bed in Dakota; but the closest parallelism is exhibited with the Lower Chalk or Turonian of Western Europe. The general *facies* of the reptilian fauna is that of the Lower Chalk, and there is little doubt that several genera are identical in the two continents, e. g. *Elasmosaurus*. The apparent peculiarity of the Chalk in America is the abundance of forms (four genera) of *Pythonomorpha* with numerous species, while but two genera have yet been found in Europe, and the presence of birds, with *biconcave* vertebræ, and teeth. This interesting type, which was first discovered by Seeley in the genus named by him *Enaliornis*, and afterwards found by Marsh to possess teeth, has been found at a lower horizon in England, the Upper Greensand. But in England, France, and Westphalia occur the genera of fishes above mentioned, as *Portheus*, *Ichthyodectes*, *Saurodon*, *Saurocephalus*, *Erisichthe*, *Empo*, *Pachyrhizodus*, *Enchodus*, *Leptotrachelus*, etc. This close relationship of the horizons permits an identification, and it is the first instance which appears to me to be susceptible of satisfactory demonstration.

The next horizon of the Cretaceous which has yielded many vertebrate remains in North America is the Fox Hills formation (including the Fort Pierre bed). Here the genus *Mosasaurus* appears in America, and is accompanied by the earliest crocodiles with procœlous vertebræ, and by numerous marine turtles which partake of the characters of both *Chelydridæ* and *Cheloniidæ*, which I have called the *Propleuridæ*. *Beryx* appears first here in America. The predominant genus of fishes is *Enchodus*, and the principal *Dinosauria* are *Lælaps* and *Hadrosaurus*. This horizon has been parallelized with the Maestricht of Europe, and several genera are common to the two beds; such are *Mosasaurus* and *Enchodus*. The genus *Hadrosaurus*, and the family of turtles I have called the *Adocidæ*, remain undiscovered in Europe; hence the identity of faunæ cannot be established.

The lacustrine beds, or summit of the American Cretaceous series, the Laramie of Hayden, present the remains of a populous fauna and a rich

flora. The students of the palæobotany have declared this flora to be of Eocene, and the later portions of Miocene character, while the lacustrine constitution of the strata has influenced the stratigraphic geologists to concur in the view that the formation should be arranged with the Tertiary epochs. That the fauna was of a mixed character is the result of a study of its vertebrate fossils. The predominant type in North America was the *Dinosauria*, which were abundant in species and individuals, and this fact alone will suffice most palæontologists as a reason for referring the epoch to the Cretaceous series. The genera of *Dinosauria* (*Palæoscincus*, *Cionodon*, *Diclonius*, *Monoclonius*, *Dysganus*, etc.) have not yet been found in any other part of the world. Mingled with them were species of crocodiles and turtles of indifferent character, while a number of other forms existed which had a limited range in time, and hence are important indicators of stratigraphic position. Such are the genera of fishes, *Myledaphus* Cope and *Clastes* Cope, which have been found also near Reims, France, by Dr. Lemoine, in the Sables de Bracheux, which are regarded as the lowest Tertiary. Such is the curious Saurian type *Champsosaurus* (Cope) (*Simœdosaurus* Gerv.), and the turtle genus *Compsemys* Leidy, which Lemoine finds a little higher up in the series, in the Conglomerate of Cerny, which is in the lower part of the Suessonian. In France, a genus of the Laramie, *Polythorax*, extends into the Lignite or upper *Coryphodon* bed of the Suessonian. Thus the Laramie is intercalated by its characters between the Cretaceous period on the one hand and the Tertiary on the other, and its fauna includes genera and orders of both great series. These relations may be exhibited in tabular form as follows. I here include the faunæ of the Sables de Bracheux and of the Conglomerate of Cerny as one, since both possess the types of the Laramie, while the horizon of the Lignite of Meudon, or the Suessonian, does not.

Sables de Bracheux and Conglomerate de Cerny.	Laramie.
a. Tertiary.	
Lophiochœrus.	
Plesiodapis.	
Pleuraspidotherium.	
Arctocyon.	
Clastes.	*Clastes.*
β. Peculiar.	
Champsosaurus.	*Champsosaurus.*
Compsemys.	*Compsemys.*
Myledaphus.	*Myledaphus.*
	Scapherpeton.

Sables de Bracheux and Conglomerate de Cerny.	Laramie.

γ. Cretaceous.

Palæoscincus.
Dysganus.
Monoclonius.
Diclonius.
Cionodon.
Lælaps.
Aublysodon.

If the Conglomerate of Cerny is the same horizon as the Conglomerate of Meudon, we must add *Coryphodon* to the upper left-hand column, and probably *Gastornis* also. The result is clear that the French and American formations together bridge most completely the interval between the Cretaceous and Tertiary series, as has been anticipated by Hayden, in America, on geological grounds. It is also evident that another formation must be added to the series already recognized in France, viz, the Laramie or Post-Cretaceous. This will be defined as the beds of the genera *Champsosaurus* and *Myledaphus*. In France, the presence of mammalia will characterize the formation as a subdivision, for which it is probable that the name Thanetian must be retained; while to the American division, which is characterized by the presence of *Dinosauria*, the name of Laramie beds has been given.

The Eocene fauna is so varied, especially in Europe, that it is necessary to compare the divisions separately, as in the case of the Cretaceous. Thus, the fauna of the Suessonian is quite as distinct from that of the Calcaire Grossier and Gypse (Parisian and Tongrian) in France as are those of the Wasatch and Bridger epochs in North America.

I have already identified the Wasatch with the Suessonian or Orthrocene, on account of the community of the following genera in the two continents: *Coryphodon*, *Hyracotherium*, *Amblyctonus*, *Clastes*, and a form of birds close to *Gastornis*. I can now add *Phenacodus*, *Orotherium* (Cope), and very probably *Hyopsodus*, *Adapis*, *Opisthotomus*, and *Prototomus*. But, as above mentioned, in the lower beds of the Suessonian in France occur genera which are, so far as yet known, wanting in the Wasatch of America, but present in the beds of the Laramie. Such are two genera in the Conglomerate of Cerny, and four genera in the lower Sables de Bracheux. In the former bed, they are associated with the mammalian genera *Lophiochœrus*, *Plesiodapis*, *Pleuraspidotherium*, and *Arctocyon;* and in the lowest, with a form referred with doubt to *Hyracotherium*. Thus the generalization may be made that the characteristic genera of reptiles and fishes of the Laramie of North America are in America associated with Cretaceous *Dinosauria*, and not with *Mammalia;* while in Europe they are associated with *Mammalia*, and not with *Dinosauria*. In arranging the Laramie Group, its necessary position is

between Tertiary and Cretaceous, but on the Cretaceous side of the boundary, if we retain those grand divisions, which it appears to me to be desirable to do. The reasons for retaining it in the Cretaceous are two, viz: (1) because *Dinosauria* are a Mesozoic type, not known elsewhere from the Tertiary; (2) because *Mammalia* (should they be found in the future in the Fort Union) are not equal as evidence of Tertiary age, since they have been also found in Jurassic and Triassic beds. The parallelism of the American Wasatch with the Upper Suessonian of France is the second identification which may be regarded as provisionally established. The only discordant elements at present known are the *Tæniodonta* of the Wasatch, which have not been so far found in Europe, and the genus *Lophiodon*, which is unknown in America.

Above the Suessonian, a divergence in the characters of the European and North American faunæ commences, and continues to be marked throughout the remainder of Tertiary time. So far as the *Mammalia* are concerned, the diversity between the continents was greater during the periods of the Upper Eocene and Miocene than at the present era. During these periods, a limited number of genera, common to the two continents, was associated with numerous genera in the one which did not exist in the other. As a consequence, our palæontological means of identification of the horizons are limited to a restricted list, and the task of applying a uniform nomenclature is, under the circumstances, difficult. Another difficulty in the way of determining the place of the American beds in the European scale consists in the fact that the physical history of the two continents during the Tertiary period appears to have been different. In America, the changes of level appear to have been more uniform in character over large areas. Each deposit has a wider geographical extent, and the fauna presents less irregular variation. In Europe we have a great number of comparatively restricted deposits, each of which differs from the others in possessing more or less peculiarity of fauna. After a study of these faunæ, their natural arrangement in Europe into three series, Eocene, Miocene, and Pliocene, does not appear to rest on any solid basis. This is especially true of the distinction between the first two; and authors are at variance as to the point of demarkation between the last two. Thus, the Tongrian is the summit of the Eocene according to Renevier, while Gaudry, with Filhol and others, places it at the base of the Miocene. One opinion is as well supported by facts, as now interpreted, as the other.

Let us now consider the nature of the evidence on which we should rely in classifying faunæ and the deposits which contain them. We are accustomed, at present, to rely for our definitions upon all the faunal peculiarities upon which we can seize: the period of appearance of certain types; the duration of certain types; and the disappearance of certain types, depending on orders, families, and genera for the major divisions, and species at a given locality for the lesser. It is, of course, evident

that either of the above-mentioned three criteria are variable quantities, since discovery is constantly extending our knowledge of the distribution of types. Hence the definitions are empirical and temporary. We must then, if we desire a stable system, examine the principles involved, and endeavor to discover definitions which stand on stronger foundations than those which we now possess.

As a matter of fact, the old definitions of epochs and periods are continually invalidated by new discoveries. As a matter of theory, this should be the case.

To the believers in the doctrine of derivation, the obliteration of faunal distinctions is not a cause of surprise. Such await with confidence the day when complete phylogenies will be possible, and at present regard the interruptions in the succession of life as local only. Will the result then be, that palæontology will cease to be available in the definition of ages and of deposits? I answer no, on various grounds. Interruptions in the succession of life in any given locality due to various causes have doubtless often occurred, and have left traces in the crust of the earth which are ineffaceable by discovery. But apart from this, one fact in this history is patent both to the friends and to the opponents of the doctrine of derivation. It is known that the world has witnessed, at every stage of its history, the extinction of some important type of life. Familiar examples are the *Placodermi* of palæozoic time, the various reptilian groups of Mesozoic time, and the *Amblypoda* of the Tertiary. Each minor subdivision of time offers its own record of persistences and extinctions of particular families and genera.

Now, all departments of biology compel us to recognize the law of classification, that the order of forms is from the less to the more generalized, from the simple to the more complex, and *vice versa*, whether the lines of succession be those of descent or of creative order; and this law is true in time as well as in classification. It follows from this, that all types of life are, at the time of their appearance, less distinct and more general in their characters than they are later in their history.

It also follows, as a consequence of the principle of descent, which states that the types of one age have taken their origin from generalized types of preceding ages, that there is no descent from the most specialized types; which is to say, conversely, that the genera, families, and orders whose extinction has been a marked feature of every geologic age have been the specialized types of those ages.

We now have a clue to a basis of a definition for faunæ, and hence for epochs, which discovery can safely build upon. The successive increments of structure by which an important modification of animal type is introduced preclude the possibility of exact determination of the time at which such type may be said to have *appeared*. Even where such a point may be arbitrarily fixed, the type must then be less char-

acteristically represented than it is at the other limit of its existence, viz, the period of its disappearance.

For these reasons I must regard the latter criterion as the true one in the discrimination of the subdivisions of geologic time, while the point of the appearance of types must be looked upon as of provisional use only, and this quite independently of the changes which discovery will from time to time compel us to make in our knowledge of the distribution of life in time and space. It must, however, be borne in mind that disappearance may be due to two causes: first, to extinction; and, secondly, to modification; a distinction which is entirely essential. The case of disappearance by modification is identical with that of appearance by modification, and cannot be used otherwise in classification. It is then the period of extinction of types to which I have reference.

With these principles in view, we continue the comparison of the extinct faunæ of Europe and North America. If we take a general view of the Tertiary faunæ, we find that the following well marked types representing families and higher groups have become extinct, and have left no living descendants or successors: Among *Insectivora*, the *Leptictidæ* in North America; also the American Bunotherian groups *Tæniodonta* and *Tillodonta;* also the *Mesodonta* of both continents; of *Edentata*, *Macrotherium* and *Ancylotherium* in Europe, and the *Megatheriidæ* in North America; among the *Carnivora*, the *Hyænodons* and *Proviverræ*, with the *Machærodi;* of *Ungulata*, the entire order of *Amblypoda*, which, however, doubtless disappeared in some of its members by modification; but its only known suborders, the *Pantodonta* and the *Dinocerata*, became absolutely extinct. Among *Perissodactyla*, both continents lost by extinction the *Chalicotheriidæ*, which terminated in a great development in North America; the genera *Hippotherium** and *Stylonus* of the line of the horses, and the *Rhinoceridæ*. Of *Artiodactyla*, two great divisions, representative of each other in the two continents, totally disappeared, viz, the *Oreodontidæ* and the *Anoplotheriidæ;* to which must be added the *Hyopotamidæ*. Of true ruminants, the most important type which has disappeared from both continents is that of the *Camelidæ*. Of Suilline genera, *Anthracotherium* and *Elotherium* may be looked upon as having left no persistent successors. Last of all, the *Proboscidea* retreated to the continents of the south.

In view of the complexity of the European record, I first present the relations of the above mentioned phenomena as displayed in the simpler American system. As the present essay commences with the earliest periods, I exhibit the succession in descending order on the page. The horizons of the Tertiary which present distinct terrestrial faunæ in North America have been named the Wasatch, the Bridger, the Uinta, the White River, the Loup Fork, the *Equus* beds, and the Champlain.

* *Equus* came through *Protohippus*, the cotemporary of *Hippotherium*.

The types which became extinct* with the close of each of these epochs are the following:

WASATCH.
- *Gastornithidæ*
- *Pantodonta.*

BRIDGER.
- *Baënidæ.*
- *Tillodonta.*
- *Mesodonta.*
- *Proviverra.*
- *Dinocerata.*

WHITE RIVER.
- *Leptictidæ.*
- *Hyænodon.*
- *Chalicotheriidæ.*
- *Hyopotamidæ.*

LOUP FORK.
- *Rhinoceridæ.*
- *Hippotherium.*
- *Stylonus.*
- *Oreodontidæ.*

EQUUS BEDS.
- *Megatheriidæ.*
- *Machærodus.*
- *Tapiridæ.*
- *Elephas.*
- *Camelidæ.*

The above table exhibits the present state of our knowledge: it will doubtless be much extended by future discovery, but not otherwise modified.

The numerous able writers on European vertebrate palæontology have more frequently recorded the appearance of types in defining their faunal divisions than their disappearance. The following table is compiled from the writings of Gervais, Gaudry, Pomel, Filhol, Renevier, and others, but is not as complete as I would desire.

SUESSONIAN.
- *Pantodonta.*

PARISIAN (Bruxellian, Bartonian, and Sestian).
- *Palæophis* (Bruxellian).
- *Proviverra.*
- *Pterodon.*
- *Mesodonta.*
- *Lophiodon* (Bruxellian).

TONGRIAN.
- *Palæotheriidæ.*
- *Chalicotherium.*
- *Anoplotheridæ.*
- *Elotherium.*

AQUITANIAN.
- *Hyænodon.*
- *Hyopotamus.*

FALUNIAN.
- *Anchitherium.*
- *Anthracotherium.*
- *Palæochærus.*
- *Cænotherium.*

OENINGIAN.
- *Ancylotherium.*
- *Dinotherium.*
- *Hippotherium.*
- *Aceratherium.*

SUBAPENNINE.
- *Mastodon.*
- *Tapiridæ.*

DILUVIAL.
- *Hyæna.*
- *Machærodus.*
- *Elephas.*
- *Rhinocerus.*
- *Hippopotamus.*

*This means, as already mentioned, the forms which left no direct successors in the Nearctic and Palæarctic Faunæ.

The above tables show that the history of mammalian life in the two continents presents many points of resemblance; but that there is a great difficulty in correlating the epochs represented by the known faunæ. As regards the two primary divisions, Eocene and Miocene, they have no special *raison d'être*, as such faunæ as the Tongrian and Oeningian are absolutely transitional in their character. More detailed comparisons of the European and American faunæ bring out many relationships not displayed by the above tables, and which I will now briefly consider.

In the American Bridger, various genera of *Mesodonta* represent the few *Adapidæ* of the Parisian, the genus *Adapis** Cuv. being probably common to the two continents. The American *Anaptomorphus*, a true Lemur, has been found by M. Filhol in the Phosphorites, and named *Necrolemur*. The characters of the numerous *Carnivora* of the Bridger are as yet unknown. The *Stypolophus* of the Bridger is perhaps the *Prototomus* of the Wasatch, and this again has been discovered by M. Filhol† in France; while a very similar, if not the same, genus has been discovered in the Swiss Siderolitic, and named *Proviverra*. *Hyænodontidæ* probably occur in the Bridger. Nowhere in Europe do we find the *Dinocerata* and *Tillodonta* of the Bridger. *Palæosyops* is also unknown in Europe, but it plays the part in America of the *Palæotherium*, from which it does not greatly differ in structure. The latter genus is most largely developed in the Parisian, but is also characteristic of the Tongrian. *Hyrachyus* is the American *Lophiodon*, the difference between them being but slight: both are found in France; the former in the Lower Parisian, the latter in the Phosphorites. *Tapirulus*‡ Gerv. is a genus common to the Bridger and to more than one horizon of the Parisian. The squirrel-like rodents of the Bridger are like those of the Parisian, but they are not confined to either epoch. The character which distinguishes the Parisian most widely from the Bridger, besides the absence of the *Dinocerata* and *Tillodonta*, is the presence of numerous Selenodont *Artiodactyla*, as *Xiphodon*, *Cœnotherium*, *Amphimeryx*, *Anoplotherium*, etc. These are of primitive type, it is true; the *Anoplotheriidæ* especially having probably four toes in the very short manus (*Eurytherium*), including the pollex, and three behind. They also display the character of a fifth crescent of the superior molars, which is wanting in the higher Selenodont types. But even these genera are absent from the Bridger. The *ensemble* is then, that the latter displays relationships backwards, or to the Suessonian, while the Parisian has a later *facies*, constituting an approach to the Tongrian and White River.§

The following table presents the relations of the Bridger fauna succinctly, but it is much less complete than we hope to make it when its

* *Notharctus* is undistinguishable from *Adapis* in inferior dental characters.

† It is described as *Cynohyænodon* with two species.

‡ Gervais, 1850; *Helaletes* Marsh, 1872.

§ See Ann. Rept. U. S. Geol. Surv. Terrs. 1873, pp. 461–2, where this view is proposed.

numerous species now represented by catalogues of names are fully described. The Parisian is here regarded as including the divisions Bruxellian, Bartonian, and Sestian (Gypse).

Parisian.	Bridger.
Didelphys.	*?Didelphys.*
Vespertilionidæ.	*Vespertilionidæ*
Plesiarctomys.	*Plesiarctomys.*
	Tillodonta.
Hyænodontidæ.	*Hyænodontidæ.*
Adapis.	*Adapis.*
Anaptomorphus (Phosph.).	*Anaptomorphus.*
	Dinocerata.
	Palæosyops.
Palæotherium.	
Lophiodon.	
Hyrachyus (Phosph.).	*Hyrachyus.*
Tapirulus.	*Tapirulus.*
Anthracotherium.	*Achænodon.*
Chœropotamus.	
Dichobune.	
Anoplotherium.	
Xiphodon.	
Amphimeryx.	

The rich Tongrian (Stampian) fauna is, according to authors, represented in the Sables de Fontainebleau, Puy en Velay, Ronzon, Hempstead, and Cadibona in Italy. We find here *Didelphys* in abundance, *Hyænodon*, *Amphicyon*, *Cynodon*, *Palæotherium*, *Paloplotherium*, *Chalicotherium*, and *Aceratherium*. Of *Artiodactyla*, the Suillines are *Anthracotherium* and *Elotherium;* the Selenodonts, *Hyopotamus* and *Gelocus*. This list is the nearest known counterpart of that of the fauna of the White River epoch of North America. To reproduce the latter, we must omit from the above catalogue the genera of *Palæotheriidæ*, and replace them by the allied Chalicotheroid *Menodus* and *Symborodon*, subtract *Anthracotherium*, and add the great body of the *Oreodontidæ*. Then there are included in the White River fauna the higher Selenodont Artiodactyles of the *Poëbrotheriidæ* and *Hypertragulidæ*, the corresponding types of which belong to the fauna of St. Gerand le Puy in France, or the Aquitanian epoch, which directly succeeded the Stampian. In Europe we have here *Dremotherium*, *Amphitragulus*, *Lophiomeryx*, *Dorcatherium;* in America, *Leptomeryx*, *Hypertragulus*, *Hypisodus*, and *Poëbrotherium*. It is curious that while *Leptomeryx* is also European,* it has not yet been found above the Phosphorites. Among Suillines, the *Palæochœrus*† of the Oregon White River beds has also not been found

* I think M. Filhol's *Prodremotherium* is identical with *Leptomeryx*.

† *Thinohyus* Marsh appears to be the same.

below the Aquitanian in Europe. But the American *Didelphys*,* *Hyænodon*, *Amphicyon*, *Elotherium*, and *Hyopotamus*, with the numerous Chalicotheroid species, show clearly that the White River fauna may be looked upon as a mixture of those of the Stampian and Aquitanian, the former of which is sometimes referred with reason to the Upper Eocene, while the latter is always left in the lowest Miocene. And the solution of this question of position as regards the White River beds appears to me to be at present by no means easy.† According to the system of Naumann, it should be called Oligocene.

Although Artiodactyles with Selenodont molars are far more abundant in both continents during this period than the last, a remarkable difference is to be observed between them. Those of Europe still largely consist of the types with five crescents, as represented by the numerous *Hyopotami* and *Cœnotheria*, while in America the modern four-crescent-bearing molar characterizes almost the entire suborder, the only exception being two species of *Hyopotamus*.

The following table will represent the relations of the White River fauna:

Stampian and Aquitanian.	White River.
Didelphys.	*Didelphys.*
	Leptictidæ.
Protomyidæ.	*Protomyidæ.*‡
	Saccomyidæ.§
Steneofiber.	*Steneofiber.*
Leporidæ.	*Leporidæ.*
Hyænodon.	*Hyænodon.*
Amphicyon.	*Amphicyon.*
Canis.	*Canis.*
	Temnocyon.
	Enhydrocyon.
Gulo.‖	*Gulo.*‖
	Dinictis.
Machærodus.	*Machærodus.*
	Chalicotheriidæ.
Palæotheriidæ.	
	Hyracodon.
	Aceratherium.
	Anchitherium.
Elotherium.	*Elotherium.*
Palæochœrus.	*Palæochœrus.*

* *Herpetotherium* Cope; *Peratherium* Aym.

† See Ann. Report U. S. Geol. Surv. Terrs. 1873, p. 462, where the White River beds are determined as Lower Miocene.

‡ *Ischyromys* Leidy.

§ *Entoptychus* and *Pleurolicus* Cope.

‖ *Amphictis* Pom.

Stampian and Aquitanian.	White River.
Anthracotherium.	
	Oreodontidæ.
Anoplotheriidæ.	
Hyopotamidæ.	*Merycopater.*
	Poëbrotherium.
Lophiomeryx.	*Hypertragulus.*
Amphitragulus.	
Leptomeryx (Phosph.).	*Leptomeryx.*
Dremotherium.	
	Hypisodus.

The Falunian epoch includes in the large sense the Langhian, Helvetian, and Tortonian divisions, embracing the rich deposits of the Orléanais, of Simorre, and of Sansan. We have here the true Miocene fauna, of which the following genera are characteristic: Edentata, *Macrotherium;* Proboscidea, *Dinotherium*, *Mastodon;* Perissodactyla, *Anchitherium*, *Listriodon;* Artiodactyla, *Palæomeryx*, *Dicrocerus*, *Procervulus;** Carnivora, *Amphicyon*, *Hyænarctos*, *? Machærodus;* Quadrumana, *Pliopithecus.* The ancient genera *Anthracotherium* and *Cœnotherium* continue throughout, and the existing genera *Arvicola*, *Lutra*, and *Sus* appear. The succeeding epoch, the Oeningian, including with it the horizons of Epplesheim and Pikermi, presents the additional genera *Dorcatherium*, *Helladotherium*, several genera allied to *Antilope*, with *Hippotherium*, the huge edentate *Ancylotherium*, and the monkey *Mesopithecus.*

It is from these materials that we must determine by comparison the American Loup Fork epoch, whose deposits are widely spread, and whose fauna is of well-marked character. Although called by my predecessors Pliocene in age, I have insisted that it should be referred to the Miocene series, and I think that the evidence to that effect, which I have produced, will be found conclusive. Nevertheless, here, as in other American Tertiary horizons, the element of geographical peculiarity enters, and diminishes the number of identical types.

Falunian.	Loup Fork.
Steneofiber.	*Steneofiber.*
Macrotherium. }	*Morotherium.*
Ancylotherium. }	
Amphicyon.	*Amphicyon.*†
Dinotherium.	*Cœnobasileus.*
Tetralophodon.	*Tetralophodon.*
Aceratherium.	*Aphelops.*
Anchitherium.	
Listriodon.	

* Gaudry, 1878; *Dicrocerus* Cope, 1874 (not Lartet); *Merycodus* et *Cosoryx* Leidy, nomina nuda.

† *Canis ursinus* Cope.

Falunian.	Loup Fork.
Hippotherium (Oeningian).	*Hippotherium.*
	Protohippus.
	*Hippidium.**
Cænotherium.	*Oreodontidæ.*
Anthracotherium.	
Palæomeryx.	*Blastomeryx.*
Dicrocerus.	
Procervulus.	*Procervulus.*
	Protolabis.
	Procamelus.

The existing genera mentioned as found in the Falunian fauna are paralleled by the *Dicotyles*, *Hystrix*, and *Mustela* of the Loup Fork beds. It is evident that this latter horizon retains in its *Oreodontidæ* the same traces of antiquity that the Falunian does in its *Cænotherium*, but shows a more modern aspect in the omission of *Anchitherium* and its replacement by *Hippotherium* and *Protohippus*, and in the still more modern type *Hippidium*. Although but six genera of the two continents are determined as identical in the above table, yet others, which are facing on the same line, are very nearly allied. Other differences are geographical. The *facies* of the Loup Fork horizon is then a compound of that of the Falunian and Oeningian, or Middle and Upper Miocene.

In commenting on the above-described fauna in 1874,† I remarked that "the proper discrimination of American Pliocene remains to be accomplished." It was not long after that date that material for making the identification of this horizon on this continent first came into my hands. This was derived from the superior Tertiary of Oregon, and includes a considerable number of species of fishes, birds, and *Mammalia*. I published a list of some of the species in 1878.‡ The character of the fauna from that region coincides with that which has from time to time been unearthed in the caves and other Eastern deposits to such an extent as to lead us to suspect that the differences between them are geographical only. In Europe, the Pliocene, or Subapennine, includes, according to D'Orbigny (1855) and Gaudry (1878), the Plaisancian and Astian, which are represented at the following localities:

Subapennine.

Plaisancian.—Montpellier; Casino (Tuscany).

Astian.—Perrier, near Issoir, Coupet, Vialette (Upper Loire), Chagny; English Crag; part of deposits of the Val d'Arno.

The characteristic of this fauna is the fact that the species belong mostly to existing genera, the chief exception being *Hippotherium*. The horses are chiefly represented by *Equus*. Common genera are *Arctomys*,

* *Pliohippus* Marsh.

† Report Lieut. G. M. Wheeler, IV, Palæontology of New Mexico, 1874, p. 364.

‡ Bull. Hayden's U. S. Geol. Surv. Terrs. iv, 1878, p. 389.

Lepus, *Elephas*, *Mastodon*, *Tapirus*, *Sus*, *Cervus*, *Antilope*, *Bos*, *Canis*, *Machærodus*, *Felis*, *Ursus*. In the *Equus* beds of Oregon, a few extinct genera in like manner share the field with various recent ones, while not a few of the bones are not distinguishable from those of recent species. I give the following list, the extinct species being in italics:

Mylodon sodalis.	Canis latrans.	*Auchenia magna.*
Thomomys (nr.) clusius.	*Elephas primigenius.*	*Auchenia vitakeriana.*
Thomomys talpoides.	*Equus occidentalis.*	*Cervus fortis.*
Castor fiber.	*Equus major.*	
Lutra near *piscinaria.*	*Auchenia hesterna.*	

The species derived from the cave formations of the Eastern States are more numerous, and differ from the Oregon fauna in many respects; yet the parallelism is close in the genera with the *Equus* beds on the one hand and the Pliocene of Europe and South America on the other. The differences distinguishing it from the *Equus* beds of Oregon are, however, such as compel me to regard it as a distinct division of the Pliocene, under the name of the *Megalonyx* beds.

Megatherium (p).	*Castoroides.*	*Machærodus* (sp).
Mylodon (p).	Lagomys (s).	*Mastodon* (sp).
Megalonyx (p).	Lepus (s).	Equus (sp).
Sciurus (s).	*Anomodon.*	*? Hippotherium* (s).
Arctomys (s).	Scalops.	Tapirus (s).
Jaculus.	*Arctotherium* (p).	Dicotyles (p).
Arvicola (s).	Procyon.	Cariacus (p).
Erethizon.	Canis (sp).	Bos (s).
Hydrochœrus (p).	Mustela (sp).	

In the above list, the extinct genera are marked in italics. There exists, as a marked feature of the North American Pliocene, to which I called attention several years ago,* a considerable representation of the fauna of the Pampean formation of South America: such are twelve genera, of which six are extinct genera, and four are peculiar to that formation and fauna. The genera found in the Pampean are marked(*p*), and those of the Subapennine (*s*). In the list from the Oregon localities, *Mylodon* and *Auchenia* were observed to be the only distinctively Pampean genera. As a conclusion of the comparison of the American *Equus* beds in general with those of Europe, it may be stated that the number of identical genera is so large that we may not hesitate to parallelize them as stratigraphically the same. On the other hand, the agreement with the South American Pampean formation is so marked in some respects as to induce us to believe that the distinction is geographic rather than stratigraphic. Believing that the Pampean formation contains too large a percentage of extinct genera to be properly regarded, as it has been, as Postpliocene or Quaternary, its characters, both essentially and as a result of the comparison which I have been able to make, refer it properly to the Pliocene.

* Proc. Acad. Phila. 1857, 156; Proc. Am. Philos. Soc. 1869, 178.

It appears, then, that the term Pliocene or Subapennine is applicable to the horizon of this fauna in Europe and North and South America.

RÉSUMÉ OF COMPARISONS.

The conclusions to be derived from the facts enumerated in the preceding pages are as follows:

I. Portions of all the faunæ of all the primary divisions of geologic time have been recognized on both the European and North American continents.

II. Parallels requiring general identification of principal divisions of these faunæ may be detected. These are: the Coal-Measures; the Permian; the Laramie; the Maestrichtian; the Eocene; the Miocene.

III. Exact identifications of restricted divisions may be made in a few instances only; such are the Turonian and the Niobrara; the Suessonian and the Wasatch; the *Equus beds* and the Pliocene.

It is not impossible that some of the relations mentioned in II will be by the accession of further information, referrible to the list of exact comparisons in III. In all cases of identification it will be necessary to employ the name first proposed with definition, for the horizon, other names taking places as synonymes. But in the majority of strata it will be necessary to preserve the local names: thus those of Judith River, Bridger, White River, and Loup Fork, applying to beds having no exact equivalents in Europe, cannot be set aside for older ones, but must themselves be applied to corresponding faunal horizons elsewhere, should any such be found in future. And it will rarely happen that the minor subdivisions of such faunæ will be found to have an extent sufficient to warrant their having other than local names.

In the accompanying diagram the series of strata of Europe and North America, as determined by their palæontology, are placed side by side for the purpose of comparison. Complete parallelism can only be predicated of divisions of the first order separated by horizontal lines. Such relation is indicated by exact opposition of the areas representing the epochs in question. In giving the minor divisions of the European epochs I have generally restricted myself to those of the epochs which have American equivalents. Where there is no equivalent on one side or the other, the vacancy is represented by a diagonal line. In employing names for epochs and their divisions, I have adhered to the law of priority as far as my knowledge of the literature allows.* I have given a few names to American formations, but only in instances where such had not been previously given. In such cases I have preferred employing the name of some characteristic genus of fossils, rather than one of local origin.

* In the European system I have been much aided by the atlas of Prof. Renevier of Lausanne, and by the writings of Woodward, Gervais, Hébert, Pomel, Gaudry, Filhol, etc.

WEST EUROPE.			NORTH AMERICA.	
Astian.	Pliocene.	Tertiary.	Pliocene.	Equus beds.
Plaisancian.				Megalonyx beds.
Oeningian.	Oeningian.		Loup Fork.	Procamelus beds.
Tortonian.	Falunian.			Ticholeptus beds.
Langhian.				
Aquitanian.	Aquitanian.		White River.	Oregon beds.
Stampian.	Tongrian.			White River.
Sestian.	Parisian.		Uinta.	Uinta.
Bartonian.			Bridger.	Bridger.
Bruxellian.				
Suessonian.	Suessonian.		Wasatch.	Green River.
				Wasatch.
Thanetian.	Thanetian.	Post-cretaceous.	? Puerco.	Puerco.
			Laramie.	Fort Union.
				Judith River.
Maestrichtian.	Senonian.	Cretaceous.	Fox Hills.	Fox Hills.
Campanian.				Fort Pierre.
Santonian.				
Turonian.	Cenomanian.		Colorado.	Niobrara.
Carentonian.				Fort Benton.
Rhotomagian.			Dakota.	Dakota.
Vraconian.	Gault.			
Albian.				
Aptian.	Urgaptian.			
Rhodanian.				
Urgonian.				
Hauterivian.	Wealden.	Jurassic.	Camarasaurus beds.	
Valangian.				
Purbeckian.	Portland.			
Portlandian.				
Kimmeridgian.				
	Corallian.			
	Oxfordian.			
	Bathian.			
	Upper Lias.			
	Lower Lias.			

WEST EUROPE—Continued.			NORTH AMERICA—Continued.	
	Rhaetic.	Trias.		
Karnian.	Keuper.		Keuper.	
Norian.				
	Muschelkalk.			
Thuringian.	Permian.	Carboniferous.	Permian.	Clepsydrops shales.
Lodevian.				Eryops beds.
Coal-Measures.	Coal period.		Coal period.	Coal-Measures.
Conglomerate.				Conglomerate.
Mountain limestone.				Mountain limestone.
Fammenian.	Upper Devonian.		Upper Devonian.	Catskill.
				Chemung.
Eifelian.	Middle Devonian.			Hamilton.
Coblenzian.	Lower Devonian.		Lower Devonian.	Corniferous.
				Oriskany.
Ledburian.	Upper Silurian.	Silurian.	Upper Silurian.	Lower Helderberg.
Ludlovian.				Salina.
Wenlockian.				Niagara.
Llandoverian.	Lower Silurian.		Lower Silurian.	Hudson.
Caradocian.				
Llandeilian.				Trenton.
Tremadocian.				
	Primordial.		Primordial.	Calciferous.
				Potsdam.
		Archæan.		

The oldest of these I have called the *Eryops* beds, from the most abundant genus of Labyrinthodonts which is found in it. They contain, also, abundance of other *Vertebrata*, none of which are higher than *Reptilia* (order *Theromorpha*), with plants, mollusks, etc. They consist of sandstones, alternating with beds of red clay and coarse conglomerate and sphærosiderite, etc. They are chiefly distributed in Northern Texas and Southern Indian Territory.

The *Clepsydrops* shale, named by me in 1865, forms a thin stratum, in Southeast Illinois and Southwest Indiana, consisting of black and rarely reddish carbonaceous shales and clays. These appear in some places to lie conformably on the Coal-Measures, to which they have been referred by previous geologists, but Collett, Gibson, and others have shown that it is unconformable over considerable areas. It does not belong to the Coal-Measures.

The Puerco marls were first observed by me in New Mexico in 1874, and afterwards found to have an extensive development in Southwestern Colorado, by Endlich, in 1875. He has referred them to the lowest place in the Tertiary series, but the absence of fossils renders it difficult to conclude whether they belong here or in the Laramie series.

The Oregon White River beds differ from those found east of the Rocky Mountains, although they contain a majority of the same genera, and many of the same species. They are wanting in the important genera *Symborodon* and *Menodus*. To represent these genera, they have *Dæodon*, and, in addition, some peculiar genera of *Rodentia*, as *Entoptychus*, *Pleurolicus*, and *Meniscomys*, and the Suilline *Palæochærus*. Among Carnivora, the genus *Enhydrocyon* is, so far as known, characteristic of them.

The Loup Fork beds are represented in the valley of Smith's River, Montana, by a horizon which may be somewhat older than that heretofore known. The fauna presents us with the typical genera *Procamelus*, *Hippotherium*, *Protohippus*, *Mastodon*, and *Merycochærus*, but, in addition, with the peculiar genera of *Oreodontidæ*, *Ticholeptus*, *Cyclopidius*, and *Pithecistes*,* and with Ruminants similar to *Palæomeryx*. These are wanting from the other parts of the formation, and I therefore name the two divisions the *Ticholeptus* and the *Procamelus* beds.

I have already mentioned the *Megalonyx* beds as the equivalents in the east of North America of the *Equus* beds of Oregon and California, but which present such important differences that they cannot be identified. The differences are displayed in the catalogues already given, the list of the *Megalonyx* fauna having been derived from the exploration of caves in Pennsylvania†, Virginia, and Illinois. The remains of this fauna are by no means found in caves only, but are found in swamps and Pliocene clays. The extinct genera characteristic of the *Megalonyx* beds are *Megatherium*, *Megalonyx*, *Castoroides*, and *Arctotherium;* the genera no longer living in North America, *Hydrochærus*, *Tapirus*.

* Proc. Am. Philos. Soc. 1877, p. 219.

† Loc. cit. 1871, p. 73.

In conclusion, it may be observed that the lacunæ in the series as presented by one continent render us dependent on the other for the evidence necessary for the complete elucidation of the laws of the creation of animal life. Phylogenies can be thus constructed which would otherwise be impossible, and the results of researches into the earliest types of *Vertebrata* become intelligible. Thus I have been able to prove, in support of a thesis published in 1874, that the earliest Ungulate *Mammalia* were pentadactyle and plantigrade. I have also shown that the ankle-joint had not, in the primitive *Mammalia*, the hinge-like character that it has in the later ones, but that it is without the interlocking superior articulation. The small size of the brain of early *Mammalia*, already pointed out by Lartet, has received extensive confirmation by the researches of Marsh, who has also shown the progressive increase in size of the whole body in various Mammalian lines. To these results I now add another, which is derived from the study of numerous Permian *Vertebrata*, viz, that the earliest land vertebrates had a persistent chorda dorsalis.

COMPARISON WITH THE SCALE DERIVED FROM PALÆOBOTANY.

I now consider another kind of relation presented by the American and European horizons. I allude to the floræ, for my knowledge of which I am necessarily dependent on the labors of others. I first exhibit the determinations of the ages of the American formations already discussed, made by Mr. Lesquereux on the basis of the vegetable remains which they contain. I place by the side of these my own determinations of the ages of the same beds, as already related. The former are derived from the full memoir of Mr. Lesquereux in the Annual Report of the United States Geological Survey of the Territories for 1872, pp. 410–417. It will be observed that there is a constant discrepancy between the two tables.

Lesquereux.	Formation.	Cope.
.....	Loup Fork	Miocene.
.....	White River	Oligocene.
Upper Miocene	Bridger	Middle Eocene.
Miocene	Wasatch ..... / Green River	Lower Eocene.
Lower Eocene	Laramie	Upper Cretaceous.

If the determinations of Mr. Lesquereux be correct,* it is evident from the above that the vegetable life of North America reached its present condition one epoch or period earlier than the higher *Vertebrata*, and that the nomenclature is thus thrown back by so much. It would appear that the recent flora of North America is a period older than the

* The above parallels are well presented by Dr. Peale in his report to Dr. Hayden, Ann. Rept. U. S. Geol. Surv. Terrs. 1874, p. 141 *et seq.*

fauna, *i. e.*, has persisted longer than the latter by a certain length of geologic time. Applying the same reasoning to the past, I embodied the idea in reference to the Laramie period ("Fort Union") in the statement that "a cretaceous fauna was then contemporary with a tertiary flora"; and, later, that "an eocene fauna was contemporary with a miocene flora." It may have to be added that a miocene fauna was contemporary with a pliocene flora. Since Mr. Lesquereux has the support of the best palæobotanists of Europe, in his conclusions, it is useless to take the ground assumed by a few of my colleagues, that the former gentleman has simply erred in his determinations. He gives us grounds for believing that he has not done so, by giving us the European standard by which his identifications are governed.* It is as follows:

Pliocene.....	Lower limits not positively fixed; largely developed in Italy. ? (Subapennine, E.D.C.)
Miocene.....	Oeningian; Mayencian; Aquitanian.
Oligocene...	Tongrian.
Eocene.....	Gypse of Aix; Alum Bay; Mt. Bolca; London Clay; Sheppey; Grès of the Sarthe.
Paleocene...	Upper Landenian; Sezanne (=Paniselian). Suessonian (Lignitic Soissonais; Sables de Bracheux); Lower Landenian. Hersian; Gelinden. Limestone of Mons, overlying unconformably the Maestrichtian.

This system, it will be observed, is almost exactly identical with that employed in the preceding pages as the standard of comparison for the *Vertebrata*. Yet it has resulted, from a most careful comparison of both faunæ and floræ of America with this standard scale, that two distinct palæontological series have to be adopted, the one for the vertebrate life and the other for the plants of the Western Continent. If this result be accurate, and there appears to be no avoiding it, an explanation must be sought. There are only two possible ones: either the animal life of North America has lagged behind that of Europe by one period during past geologic time; or, secondly, the vegetable life of America has been equally in advance of that of Europe during the same period. In other words, if the plant-life of the continents was contemporaneous, ancient types of animals remained a period longer in North America than in Europe. If animal life was contemporaneous, plant-life had advanced by one period in Europe beyond that which it had attained in North America. In either case, the faunal or the floral standard of estimation of geologic age of strata for North America is a false one, since there can be but one standard of comparison for anything. But this great fact being understood, the evidence of each of the great departments of life possesses its own intrinsic value.

*Ann. Report U. S. Geol. Surv. Terrs. 1874, p. 285.

Art. III.—Observations on the Faunæ of the Miocene Tertiaries of Oregon.

By E. D. Cope.

A considerable number of *Vertebrata*, almost exclusively *Mammalia*, have been described by authors from the White River and Pliocene formations of Oregon. The descriptions are found in Professor Leidy's contribution to the Final Report of the United States Geological Survey under Dr. Hayden (Vol. I); in those of Professor Marsh in the American Journal of Science; in a paper by Mr. Bettany in the Quarterly Journal of the Geological Society of London for 1876; and in a paper by myself (Paleontological Bulletin No. 30) in the Proceedings of the American Philosophical Society, published in December, 1878.* Having recently had the opportunity of inspecting a considerable amount of material from the horizons in question, I give a list of the species which I have observed. A few new ones occur in collections received since the publication of my last paper, and are now described, together with some of interest from the Loup Fork beds of the same region.

White River Fauna.

TESTUDINATA.

STYLEMYS OREGONENSIS Leidy.

RODENTIA.

STENEOFIBER GRADATUS Cope.
STENEOFIBER ? NEBRASCENSIS Leidy.
MENISCOMYS HIPPODUS Cope.
MENISCOMYS MULTIPLICATUS Cope.
PLEUROLICUS SULCIFRONS Cope.
ENTOPTYCHUS CAVIFRONS Cope.
ENTOPTYCHUS PLANIFRONS Cope.
ENTOPTYCHUS CRASSIRAMIS Cope.
PALÆOLAGUS HAYDENI Leidy.

*See also the American Naturalist, December, 1878.

CARNIVORA.

HOPLOPHONEUS BRACHYOPS Cope.

MACHÆRODUS STRIGIDENS Cope.

ENHYDROCYON STENOCEPHALUS, gen. et sp. nov.

Generic Characters.—Dental formula: I. ?; C. $\frac{1}{1}$; Pm. $\frac{3}{3}$; M. $\frac{2}{?}$. The superior premolars consist of two ordinary and one sectorial; the first and second are both compressed, two-rooted, and in the typical species with median lobe of posterior cutting edge. The two true molars are transverse and tubercular. The three inferior premolars are all two-rooted, and with posterior lobe in the two known species. The heel of the sectorial is cutting, as in *Temnocyon*, and the internal tubercle is present. There is at least one inferior tubercular tooth; specimens are injured so as not to display a second.

In a nearly complete cranium belonging to the typical species of this genus, we observe the shortness of the facial part of the skull as compared with the length of the cerebral, and also the constriction of the skull behind the orbits. The zygomatic arches are robust and expanded, and the sagittal crest is high. The auditory bullæ are inflated and thin-walled.

The dentition of this genus refers it to the *Canidæ*, but the form of the skull resembles that of *Putorius vison* and *Lutra*.

Specific Characters.—The principal cusps of the inferior premolars present cutting edges, as does the median posterior lobe. In both third and fourth there is a small conic heel posteriorly, but an anterior basal tubercle on the fourth only. The sectorial is large and robust, and the heel is short, with an absolutely median cutting edge. The first tubercular is longer than wide, and presents a nearly median cusp in front, which is joined to a low one on the internal border of the crown.

The superior canine has an obtuse cutting edge on the anterior and posterior borders of the inner side. The first (third) superior premolar is near to it, and is rather large, displaying a median cutting lobe and low posterior heel. The fourth is similar but larger. The sectorial is much worn in the only specimen where it is preserved; it is rather short, and is widened anteriorly. The first tubercular is large, and has considerable transverse extent; it is a little wider externally than internally, and has much the form of the corresponding tooth in *Canis*. The second tubercular is transverse and small, not being much more than half the length of the first, and is situated in contact with it.

The cranium is remarkable for the anterior position of the orbits, and the associated shortening of the face and lengthening of the parietal region. The orbits look somewhat forwards and very little upwards. The superciliary region is slightly prominent, and there is a prelachrymal concavity. The infraorbital foramen is moderate, and is situated mostly above the posterior part of the fourth premolar. The muzzle is flat

above, and the nasal bones are wide, and are not emarginate above the osseous nares, as in many recent *Carnivora*. Posteriorly, the superior border of the brain-case descends, but the parietal bones maintain a gently convex outline in their high sagittal crest. The supraoccipital region is elevated, and projects posteriorly.

Measurements.

Specimen No. 1.

	M.
Antero-posterior diameter of second superior premolar	0.010
Antero-posterior diameter of third inferior premolar	0.013
Width of base of third inferior premolar	0.0065
Elevation of crown of third inferior premolar	0.010
Diameter of inferior sectorial, transverse	0.010
Diameter of inferior sectorial, antero-posterior	0.021
Width of first tubercular	0.006

Specimen No. 2.

Total length of cranium	0.170
Width across zygomatic arches	0.114
Least width behind orbits	0.024
Depth of cranium with crest at otic bulla	0.070
Vertical diameter of orbit	0.025
Length from orbit to end of muzzle (axial)	0.040
Interorbital width	0.043
Width of muzzle above second premolar	0.018
Length of superior molar series	0.051
Length of fourth premolar	0.012
Length of sectorial	0.016
Length of first tubercular	0.008
Width of first tubercular	0.015
Width of second tubercular	0.0085

The length of the skull is about that of the Coyote, but it is much more robust in all its proportions excepting the postorbital constriction.

Discovered by Charles H. Sternberg in the Oregon White River beds of the John Day River region.

ENHYDROCYON BASILATUS, sp. nov.

This Carnivore is represented by a mandible with coössified rami, which are broken off behind the sectorial teeth. The crowns of the latter and but one incisor and one canine tooth remain. The premolars and one canine are in good preservation.

These portions indicate an animal of the same general character as the *Enhydrocyon stenocephalus*, but of larger and more robust proportions, and characterized by many dental peculiarities. These will be at once pointed out. The canine is directed upwards and a little outwards, and possesses two obtuse ridges bounding the interior face. The third incisor is compressed and truncate superiorly and distally. The first (second) premolar is two-rooted, compressed, and trilobate. It consists of a principal cutting edge little elevated, and a small accessory lobe

at each extremity of the crown; its base is expanded posteriorly. The principal cusp of the third premolar is more elevated, and, besides the anterior and posterior tubercles, there is a basal posterior heel, which is continued as an expansion of the inner base of the crown. In the fourth premolar, the base of the crown is expanded, especially posteriorly; the principal cusp has a nearly circular section at the base, and the posterior median lobe is a subconic tubercle standing on the middle of the heel. The sectorial is large and relatively rather narrow, but the details of its form are not ascertainable.

Measurements.

	M.
Length of dental series, including canine and sectorial	0.076
Length of the base of the sectorial	0.024
Length of the premolar series	0.037
Length of the fourth premolar	0.016
Width of the fourth premolar	0.009
Length of the third premolar	0.013
Width of the third premolar	0.008
Length of the second premolar	0.009
Width between centres of crowns of fourth premolars	0.034
Length of symphysis	0.035

This species was probably of the dimensions of the Gray Wolf. Found by Mr. Sternberg in the same region as the *E. stenocephalus*.

TEMNOCYON ALTIGENIS Cope.

CANIS HARTSHORNIANUS Cope

CANIS GEISMARIANUS Cope.

CANIS CUSPIGERUS Cope.

CANIS LIPPINCOTTIANUS Cope.

CANIS GREGARIUS Cope.

PERISSODACTYLA.

DÆODON SHOSHONENSIS Cope.

ACERATHERIUM PACIFICUM Leidy.

ANCHITHERIUM EQUICEPS Cope.

ANCHITHERIUM BRACHYLOPHUM Cope.

ANCHITHERIUM LONGICRISTE Cope.

ARTIODACTYLA.

ELOTHERIUM IMPERATOR Leidy.

PALÆOCHŒRUS CONDONI Marsh.

PALÆOCHŒRUS PRISTINUS Leidy.

PALÆOCHŒRUS SOCIALIS Marsh.

MERYCOPATER GUYOTIANUS Cope.

EUCROTAPHUS SUPERBUS Leidy.

EUCROTAPHUS OCCIDENTALIS Marsh.

MERYCOCHŒRUS LEIDYI Bettany.

MERYCOCHŒRUS TEMPORALIS Bettany.

POËBROTHERIUM STERNBERGII, sp. nov.

This Ruminant is represented by a considerable part of the skeleton with both mandibular rami supporting the teeth, of one individual. The bones are all in close proximity, and sometimes in undisturbed relation, in a single block of stone.

The species to which I give the above name presents the characters already ascribed to the genus *Poëbrotherium* by Leidy as regards cranial features, and by myself as regards the rest of the skeleton. The third and fourth metacarpals are not coössified, and the second and fifth are not distinguishable. The preservation of the premaxillary bone in this species enables me to demonstrate the presence of superior incisor teeth, a character the presence of which I have heretofore only inferred. As compared with the *P. vilsoni*, the species differs in its superior size and greater relative robustness. This is seen in the greater depth of the mandibular ramus, and the greater stoutness of the metapodial and other limb-bones. The last inferior molar tooth presents a characteristic peculiarity. The anterior external cusp is separated by a deep groove which divides the external side of the crown to the base from the succeeding cusp. It results that on trituration, the anterior external crescent is isolated, and does not communicate by its posterior horn with the succeeding crescent, as in *P. vilsoni*. The last premolar is more robust than that of the *P. vilsoni*, the width of the half-worn surface being half the length of the tooth and enclosing behind an enamel fossa. In *P. vilsoni*, this tooth is more compressed, and the fossa is represented by an open groove. The first inferior premolar occupies the middle of the diastema following the canine, instead of standing near the canine as in *P. vilsoni*.

Measurements.

		M.
Diameter of last molar	antero-posterior	0.020
	transverse	0.009
Diameter of penultimate molar	antero-posterior	0.013
	transverse	0.009
Depth of ramus at second molar		0.025
Length of ramus from third molar to extreme posterior edge		0.061
Length of metacarpus		0.178
Transverse proximal diameter of the two metacarpi		0.029
Greatest diameter of the head of the humerus		0.053
Antero-posterior diameter of the condyle of the femur		0.048

This species is named in honor of Charles H. Sternberg, the indefatigable explorer of the fossil deposits of the West.

BOÖCHŒRUS HUMEROSUS, gen. et sp. nov.

Generic Characters.—The species on which this genus is founded, is represented by a part of the skeleton, which is unfortunately not accom-

panied by cranial bones or teeth. The characters are, however, sufficiently clear for purposes of determination. The great tuberosity of the humerus is produced beyond the head, and does not close round the bicipital groove. The intertrochlear ridge is well developed, and there is no internal epicondyle; the external epicondyle is moderately developed. On the carpal extremity of the ulno-radius, the facets of the scaphoid, lunar, and cuneiform bones, are distinguished by strong oblique ridges, and the last named is nearly in the horizontal line of the two others. In the carpus, the trapezoides is distinct, and the trapezium wanting. The unciform is in contact with the lunar. Metacarpals two, distinct from each other, with free rudiments of the second and fifth at their proximal extremities. Their distal keels confined to the posterior faces of their extremities. Phalanges depressed; ungues short, obtuse.

In the above description is found a combination of characters not known to me to exist in any recent or extinct genus of *Artiodactyla*. Several of its features indicate affinity to the suilline division, while others point to the *Ruminantia*. The imperfect distal articulation of the metacarpals is characteristic of the extinct types *Oreodontidæ* and *Poëbrotheriidæ*, and the two distinct metacarpals constitute the resemblance to the latter family the stronger. The latter character is, however, not inconsistent with the *Omnivora*, and the depressed phalanges add to the weight of affinity in this direction. The distal extremity of the humerus is much like that of a peccary. The distal articular surface of the ulno-radius points, however, again to the *Ruminantia* of the group *Pecora*, displaying a specialization quite in contrast with the primitive character of the metacarpo-phalangeal articulation. From these considerations it can be seen that it is not easy to affirm whether this genus possesses bunodont or selenodont dentition. If I may venture an inference as to the affinities of the genus, I would suggest that it will be found to be as nearly allied to the *Hypertragulidæ* as to the *Oreodontidæ*, though not without suilline affinities.

Specific Characters.—The only species of this genus known to me is of large size. It is represented by the greater part of a scapula and both anterior limbs and feet; by the pelvis, femur, and part of tibia, and by some vertebræ; all found in immediate association by Mr. Sternberg. These remains indicate an animal of the size of the *Rhinocerus indicus*. The animal is characterized by the massive proportions of the humerus as compared with the femur, and by the short, robust form of the metacarpals.

In the *humerus*, the external border of the great tuberosity is entire, and is not reverted, but descends backwards like the remainder of the surface. The apex of the great tuberosity is much recurved, rising steeply proximad of the head. The bicipital groove is deep. The lesser trochanter is large and simply conic; its transverse extent is not great. External to its base is a small tuberosity, which is represented in *Bos*, but not in *Dicotyles* or *Sus*. The deltoid crest is very prominent, de-

scending to the middle of the length of the humerus, before abruptly sinking to the shaft. Its continuation is very prominent as it crosses the axis of the shaft and becomes the anterior bounding ridge of the internal side of the distal extremity. The section of the shaft is thus subtriangular at all points, the obtuse apex of the triangles revolving from the external side proximally, to the internal distally. The external epicondyle is proximal to the condyle, as in *Dicotyles*, but is more prominent than in that genus, and more as in *Oreodon*. It is the extremity of the external acute edge of the humerus, which, rising from the shaft at a point 90° posterior to the extremity of the deltoid ridge, turns forwards to the external epicondyle. The condyles are transverse and not much contracted from side to side. The intertrochlear ridge is sharper than in the species of *Oreodon*, *Dicotyles*, or *Sus*, and is continued round to the shaft anteriorly, as in *Bos*. The condyles otherwise resemble those of *Dicotyles*, not being so contracted in their free margins as in *Bos*.

Measurements of the Humerus.

		M.
Total length		0.500
Length from middle of head		0.425
Diameter of proximal end	antero-posterior	0.140
	transverse	0.170
Diameter of head	antero-posterior	0.100
	transverse	0.100
Width of humerus near extremity of deltoid crest		0.130
Diameter of shaft just below extremity of deltoid crest	antero-posterior	0.078
	transverse	0.065
Width at epicondyle		0.130
Transverse diameter of condyles		0.120
Antero-posterior diameter of condyles	internally	0.070
	at constriction	0.055
	externally	0.050

This bone has about the size of the corresponding one of the *Rhinocerus indicus*.

The carpal extremity of the *ulno-radius* is extended transversely. The cuneiform or ulnar articular face forms posteriorly two-fifths the entire extremity, and is only recurved in the external part of its posterior border, which is very concave. The ridge which separates it from the lunar surface is very oblique, following just outside of the ulno-radial suture, and contracting the cuneiform facet anteriorly. Distally and posteriorly it forms the external border of the posteriorly reverted lunar facet, bounding a deep fossa, which is posterior to the cuneiform facet on its inner side. The lunar facet widens behind at the expense of the scaphoid, so that the scapho-lunar ridge is even more oblique than the luno-cuneiform. This ridge disappears supero-anteriorly, and the lunar facet is recurved upwards, occupying the distal extremity of a strong median ridge of the ulno-radius. The reverted portion is almost a half circle in outline, and is partly continuous with the scaphoid facet. The

latter is subtriangular in outline, its apex being the point of conjunction of the scapho-lunar ridge with the internal border, just posterior to its greatest convexity. Its superior boundary is interrupted by the wide groove which separates the median ridge from the internal border of the distal part of the radius.

Measurements of the Ulno-radius.

		M.
Transverse diameter, total		0.110
Transverse diameter of ulna		0.050
Antero-posterior diameter of articular face	externally	0.035
	at middle of ulna	0.021
	at luno-cuneiform ridge	0.055
	internally	0.045

But for the extent and transverse position of the ulnar portion of this articular face, it might be regarded as pertaining to a typical Ruminant.

The length of the *carpus* is about three-fourths its width, the proximal elements being larger than the distal. A feature of its anterior face is the close approximation of the inferior angle of the lunar to the superior angle of the third metacarpus, which allows the magnum and unciform a very slight contact. The external face of the scaphoid is chiefly lateral; its posterior border is a vertical, short tuberosity. The proximal face is abruptly decurved at the anterior outer angle, to meet the lunar. There are two separate oval superior lunar facets, and one narrow anterior inferior one. The inferior face is nearly equally divided by a low cross ridge which fits a concavity of the posterior part of the magnum. The lunar is the largest bone of the carpus. Its proximal face is decurved anteriorly, posteriorly, and on each side, and is twice as long as wide at the middle. The postero-internal and antero-external angles are produced, the latter into a compressed process which articulates with the adjacent angle of the cuneiform. Besides this facet there is one other for the cuneiform, which occupies the posterior half of the inferior part of the outer side, and is separated from the superior edge by a deep groove. The unciform facet is in front nearly as wide as that of the magnum, but grows gradually narrower posteriorly. The facet for the magnum is concave, and grows very wide posteriorly, with the posterior internal angle produced downwards. The proximal facet of the cuneiform is very concave, the anterior and posterior borders being elevated, and the internal and external decurved; the latter prolonged a little backwards. Below this extremity on the external aspect is a fossa. The pisiform facet makes an angle of 90° with the ulnar, and extends behind and along the posterior edge of the latter to its apex. The unciform facet is simple, and is in shape a right-angled triangle with convex hypothenuse. The posterior aspect of this bone is concave.

The proximal face of the trapezoides is longer than wide, convex antero-posteriorly, and subdiamond-shaped. The inferior face is narrow subdiamond-shaped, and has less than half the area of the proximal. There is a small round tuberosity on the posterior border, and no trace

of facet for a trapezium. The anterior face of the magnum is wider than long, and is divided into three planes. The proximal extremity is divided into two areas by a high antero-posterior keel. The inner area is the larger, and is bounded by the entire superior border of the anterior face of the bone. The outer area, or the lunar facet, extends very obliquely downwards, most so in front, where it forms the external side of the magnum. It is interrupted by a large sinus, which leaves the posterior portion of the face narrow and transverse. Behind it is first a fossa and then two short tuberosities, one above and external to the other. The inferior face is undivided, and is concave antero-posteriorly, and convex transversely. The unciform is the second bone of the carpus in size. Its anterior face is broader than long, and is convex transversely. The inner face has in front a large trapezoidal facet for the third metacarpus, which is only separated from that of the lunar by the angle. The superior face is divided, by an angular ridge nearly parallel with the inner border, into two unequal faces for the lunar and cuneiform. The latter is half as wide posteriorly as long, and terminates anteriorly in an obtuse angle. The distal face is undivided, but is recurved postero-externally, apparently offering a narrow facet for the fifth metacarpus. This face nearly meets the cuneiform face posteriorly. Behind both the unciform is produced into a decurved, subconic tuberosity.

*Measurements of the Carpus.**

			M.
Diameter of scaphoid	antero-posterior		0.066
	longitudinal		0.048
Diameter of proximal face of scaphoid	antero-posterior		0.048
	transverse		0.030
Diameter of distal face of scaphoid	antero-posterior		0.048
	transverse		0.023
Diameter of proximal face of lunar	transverse	anteriorly	0.047
		at middle	0.032
	longitudinal		0.053
Diameter of anterior face of lunar	longitudinal		0.048
	transverse		0.032
Diameter of cuneiform	antero-posterior, oblique		0.059
	transverse, behind		0.040
Diameter of proximal face of cuneiform	antero-posterior		0.040
	transverse		0.044
Diameter of distal face of cuneiform	antero-posterior		0.040
	transverse		0.031
Length of trapezoides			0.027
Diameter of proximal face of trapezoides	antero-posterior		0.029
	transverse		0.016
Diameter of distal end of trapezoides	antero-posterior		0.020
	transverse		0.010
Diameter of magnum	longitudinal	anteriorly	0.029
		externally	0.040
	transverse, posteriorly		0.047
	antero-posteriorly, outer side		0.055

* These measurements are always the greatest, and are axial, or in straight lines.

Measurements of the Carpus—Continued.

		M.
Diameter of lunar face of magnum	antero-posteriorly	0.046
	transversely	0.031
Diameter of distal face of magnum	antero-posteriorly	0.040
	transversely	0.048
Diameter of unciform	antero-posterior	0.080
	transverse	0.053
	longitudinal, in front	0.040
Diameter of lunar facet	antero-posterior	0.047
	transverse (least)	0.016
Diameter of cuneiform facet	antero-posterior	0.052
	transverse (behind)	0.028
Diameter of 4th metacarpal facet	antero-posterior	0.044
	transverse	0.046

As already remarked, this carpus displays resemblances to some recent types, and possesses some which are not known among living *Artiodactyla*. The inferior face of the scaphoid is narrower from side to side than in the *Ruminantia* or *Sus*, *Dicotyles* only approaching but not equalling it in this respect. The strong inferior keel of the lunar exceeds that seen in any of the *Ruminantia* or *Omnivora*. The pisiform facet is more oblique than in those groups. The posterior tuberosities of the magnum and unciform are larger than those of the genera of either group, while the distinct trapezoides, the slightly shortened magnum and unciform, and slight decurvature of the cuneiform facet of the unciform posteriorly, are suilline characters.

The *metacarpals* are robust, but flattened antero-posteriorly. The rudiments of the second and fifth are free, and the latter is the larger. The third has a considerable surface of contact with the unciform; its anterior face displays two shallow fossæ, one at each superior angle. The corresponding positions on the fourth metacarpal are occupied by two low bosses. Otherwise the surfaces of the shafts of these bones are uniform. The phalangeal articular face is well reverted anteriorly and posteriorly, and is not bounded by a transverse depression anteriorly above. The carina is short, though prominent, and extends to the middle of the distal extremity. The lateral distal tuberosities are very low.

Measurements of the Metacarpals.

		M.
Length of M. III		0.210
Length of M. IV		0.190
Diameter of M. III proximally	transverse (total)	0.063
	antero-posterior	0.055
Diameter of M. III distally	transverse	0.053
	antero-posterior (chord)	0.045
Diameter of M. IV proximally	transverse	0.054
	antero-posterior	0.045
Diameter of M. IV distally	transverse	0.043
	antero-posterior (chord)	0.048
Length of M. II		0.055
Length of M. V		0.040
Diameter of M. V antero-posteriorly		0.021

The *phalanges* are more depressed than in any genus of *Artiodactyla* known to me, excepting *Hippopotamus*. The proximal articular surface of the first is gently concave, with the anterior border not produced. The shaft is not contracted, and is regularly convex above or anteriorly. The distal articular face is narrower above and not produced. The superior border of the proximal face of the second phalange is produced medially. The distal face is narrowed and produced upwards, so as to stand in high relief, from which it results that the middle of the shaft is very concave above. The external and internal borders of the inferior or posterior part of the distal face, are produced backwards, covering lateral basal ridges of more than half the length of the shaft, which form the inferior border of lateral fossæ. One unguis is preserved. It is distinct in form from that of *Hippopotamus*, *Sus*, or *Dicotyles*, and resembles that of the llama. It is short, obtuse, and compressed. The external face is nearly plane fore and aft, and slightly convex vertically. The inner is convex fore and aft, and concave vertically. The profile descends steeply to the apex, the curve commencing but little beyond the base. The inferior face is at right angles to the interior face, and is moderately wide.

Measurements of the Phalanges.

		M.
Median length of first of M. IV		0.066
Proximal diameter	antero-posterior	0.042
	transverse	0.055
Distal diameter	antero-posterior (median)	0.030
	transverse (greatest)	0.055
Median length of second phalange		0.055
Diameter of second phalange proximally	antero-posterior	0.035
	transverse	0.045
Diameter of second phalange distally	antero-posterior	0.032
	transverse	0.041
Length of ungual phalange below		0.042
Proximal diameter of ungual phalange	antero-posterior	0.032
	transverse	0.025

The *femur* is slender as compared with the humerus, and of moderate length. The great trochanter is produced, but not beyond the line of the convexity of the head, and is not much recurved. The expanse externally is about as great as that of the head internally. The trochanteric fossa is not large, and is cut off below by a plane surface at the base of the great trochanter, whose superior border forms a curved line connecting the great and little trochanters. The latter is large and projects well inwards. The *fossa ligamenti teris* is large and central, having no connection with the border of the head of the femur. The posterior side of the shaft is flat, and the anterior face regularly convex. The two faces meet externally in a well-marked representative of the *linea aspera*. The rotular face of the femur is short and wide, with the borders somewhat oblique, and the inner edge is higher than the outer at its proximal part. It is strongly convex from above downwards, and

does not connect below with the condylar surfaces. Its entire inferior border is well defined and angulate. The condyles are well separated, and the intercondylar fossa is wide above or anteriorly. The external is a little the larger, and the internal is distinguished by the presence of a deep lateral fossa.

The head of the *tibia* is characterized by a distinct bifid spine, and a low, wide crest, which presents an open, shallow groove forwards. The articular faces are of subequal width, but the external is shortened anteriorly by the usual notch; it is also decurved posteriorly.

Measurements of the Femur.

	M.
Expanse proximally (greatest)	0.170
Expanse proximally at extremity	0.150
Diameter of head	0.068
Diameter of shaft at middle { antero-posteriorly	0.053
Diameter of shaft at middle { transversely	0.060
Length of chord of rotular face	0.088
Width of rotular face	0.070
Expanse of condyles (greatest)	0.122
Greatest chord of distal end of femur	0.110

Measurements of the Tibia.

	M.
Diameter of head of tibia { antero-posterior	0.130
Diameter of head of tibia { transverse	0.125

The form of the head of the tibia is much like the corresponding region in *Oreodon culbertsoni;* but the characters of the femur do not resemble those of that species, particularly as regards the distal extremity.

A peculiarity of the long bones of this species is seen in their very large medullary cavities. This is especially true of the humerus, whose walls are remarkably thin; those of the femur are thicker.

This species was found by Mr. C. H. Sternberg in the John Day River region.

LEPTOMERYX EVANSI Leidy.

HYPERTRAGULUS CALCARATUS Cope.

This species is much more abundant in the John Day River deposit than the *Leptomeryx evansi.* The two genera represent a peculiar family, which I call the *Hypertragulidæ*, with the following characters:

Selenodont *Ruminantia* with an interrupted dental series, coössified ulna and radius, cuboid and navicular bones, and third and fourth metapodial bones. Only two continuous metapodial bones, their distal articular extremities not presenting a complete trochlear keel. No fibula. Premolars except the fourth, cutting.

This family connects the *Tragulidæ* with more typical *Ruminantia.* It differs from that family in the absence of the fibula and the external metapodial bones. From the typical *Ruminantia* or *Pecora*, it differs

in the incompleteness of the trochlear keel of the metapodials, and the trenchant character of the premolars, excepting the last.

The species of the preceding list which I have observed in other localities are the following, which I procured in the White River beds of Eastern Colorado: *Palæolagus haydeni*, *Canis hartshornianus*, *Canis lippincottianus*, *Canis gregarius*, *Leptomeryx evansi*, *Hypertragulus calcaratus*. Professor Leidy has recognized a number of species as those previously found in the White River beds of Dakota by Dr. Hayden.

Loup Fork Fauna.

Two new species were obtained by Mr. Sternberg at this horizon, which present characters of considerable interest. They are as follows:

LUTRICTIS? LYCOPOTAMICUS, sp. nov.

This Carnivore is represented by a left mandibular ramus, which contains alveoli and crowns of the canine and molars, excepting those posterior to the sectorial. These teeth have the formula, four premolars, of *Mustela* and of the Dogs, but the sectorial is much more like that of *Lutra* than that of either of the genera named. The heel of this tooth is long, and encloses a wide space transversely, while the sectorial portion is short and low, and includes a large internal tubercle. In the absence of the tubercular teeth, the generic reference is uncertain; but its characters agreeing, so far as they go, with the genus *Lutrictis* of Pomel, I refer it there provisionally.

The first premolar only is one-rooted; the third is wide behind, developing a low heel. The heel of the fourth is a little better developed, and there is a small anterior basal cutting lobe; there is also a tubercle on the posterior cutting edge at the middle. The three cusps of the anterior part of the sectorial tooth are situated at the corners of an imaginary equilateral triangle. The heel continues the width of the crown, is wider than long, and is abruptly truncate behind. It supports a long cutting edge just within the external border, and a shorter one on the internal. The surface of the enamel is smooth. There are two mental foramina, one below the interval between the first and second premolars, the other beneath the anterior root of the third premolar.

Measurements.

	M.
Length of molar series without tubercular	0.0220
Diameter of sectorial, antero-posterior	0.0066
Diameter of sectorial, transverse	0.0040
Length of heel of sectorial	0.0024
Length of fourth premolar	0.0045
Elevation of fourth premolar	0.0036

From the Loup Fork formation of Cottonwood Creek, Oregon; discovered by Charles H. Sternberg.

PROTOLABIS TRANSMONTANUS, sp. nov.

A nearly complete cranium, without lower jaw, of an adult animal, is

the basis of our knowledge of this species. It presents the characters of the genus in the following superior dental formula: I. 3; C. 1; P.m. 4; M. 3. The first premolar is situated in the middle of a long diastema, and a short one separates the canine from the third incisor.

On comparison of this species with the *P. heterodontus*, the type, and heretofore the only known species of the genus, various characteristic peculiarities may be observed, which will be noticed in the course of the description. It is considerably smaller than the *P. heterodontus*, resembling in its dimensions the *Procamelus occidentalis*.

The crown of the second superior incisor is directed forwards, and the cutting edge is oblique to the long axis of the tooth. The first incisor is equally large, and its alveolus occupies the apex of the premaxillary bone. In *P. heterodontus*, the alveolus is smaller, and the apex extends considerably beyond it. The third incisor has a conic crown, with subround section. In *P. heterodontus* it is more robust, and is oval in section, with weak posterior cutting edge. The canine is less robust than the third incisor, and is about as far posterior to it as the latter is from the second incisor. The crown is slightly compressed, and is less robust than that of *P. heterodontus*. The first premolar is still weaker, and the crown is compressed; the roots are only discrete at their extremities. It is situated a little more than one-third the distance between the canine and second premolar behind the former. The second premolar is well developed, and is two-rooted. The third premolar is also large, with the grinding surface of the crown about half as wide as long. It has a strong internal basal cingulum, which on attrition encloses a groove-like fossa with the principal crown. The external face of the crown is gently convex between an anterior and a posterior ridge. The internal face of the crown is uniformly convex. The fourth premolar has both crescents well developed. Its grinding face is subsemicircular, and there are a strong anterior and a weak posterior external vertical ridge. In *P. heterodontus*, the grinding surface of this tooth is more nearly subquadrate.

The true molars are subquadrate in horizontal section, and have short crowns, well distinguished from the roots. The anterior horn of each external crescent is prolonged, constituting a section of a prominent vertical external ridge of the crown at each point. The external sides of the columns are but slightly convex. The inner sides of the internal columns are strongly convex. The enamel borders of the lakes are absolutely simple, and there are no included enamel fossæ. The posterior outer angle of the last superior molar is not produced.

As compared with the true molars of *P. transmontanus*, those of the *P. heterodontus* are relatively smaller in transverse diameter. The masticating surfaces of the crowns of the second and third are thus more elongate in outline. They are also rather more prismatic, and the last two apparently occupied longer time in the process of protrusion. They are much larger than those of *P. transmontanus*.

The *foramen infraorbitale* issues above the middle of the fourth pre-

molar. In *P. heterodontus* it issues above the anterior part of the first true molar. A sharp angle separates the exterior and extero-inferior faces of the malar bone.

Measurements.

	M.
Length of dental series from base of first incisor	0.257
Length of incisors on chord	0.028
Space between third incisor and canine	0.006
Length of crown of third incisor	0.013
Antero-posterior diameter of third incisor	0.008
Length of interval between canine and first premolar	0.011
Length of interval between first premolar and second premolar	0.020
Length of three contiguous premolars	0.035
Length of third premolar	0.014
Width of third premolar (greatest)	0.0075
Length of true molar series	0.057
Diameter of second true molar, antero-posterior	0.018
Diameter of second true molar, transverse	0.018
Diameter of third true molar, antero-posterior	0.022
Diameter of third true molar, transverse	0.019

Discovered by C. H. Sternberg in the Loup Fork beds of Cottonwood Creek, Oregon.

ON THE

Extinct Cats of America.

BY

E. D. COPE.

From the American Naturalist, for December, 1880.

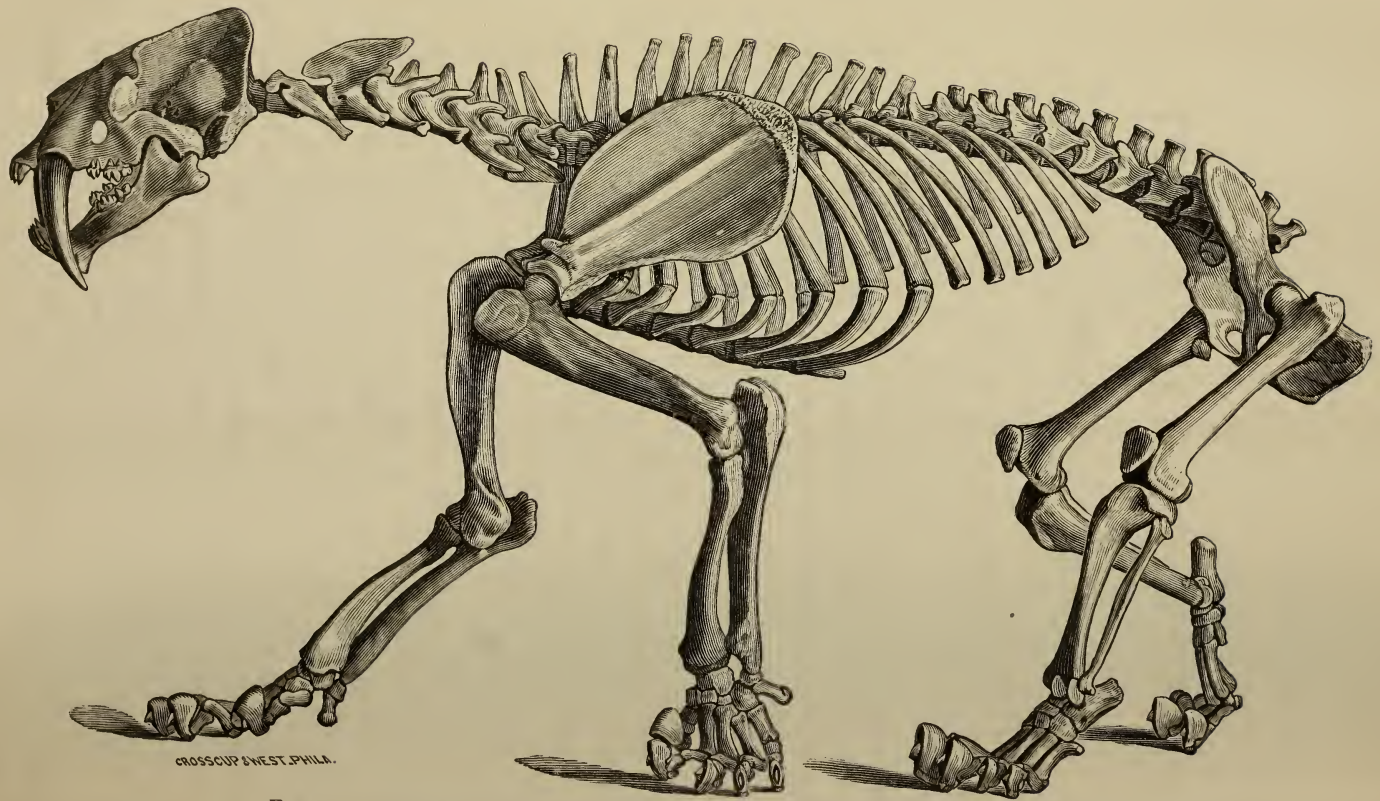

FIG. 12.—*Smilodon necator* Gervais, less than one-ninth natural size. From Burmeister.

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ON THE EXTINCT CATS OF AMERICA.

BY E. D. COPE.

IN following the general series of the *Carnivora*, we pass, as in other orders, from the generalized to the specialized types. That we should begin with the *Procyonidæ* (raccoons) and their allies, is indicated by all the characters to be especially considered in the case. They have five toes on all the feet and are plantigrade, resembling in these points all primitive *Mammalia*.[1] They have the original number of molar teeth, seven on each side, and of these none are distinctly developed sectorials. The condyloid and carotid foramina are distinct, and there is a postglenoid foramen. If, starting from this point of departure, we arrange the succeeding families of *Carnivora* according to their resemblances and differences in these respects, we have a tolerably consecutive series of divisions.

Passing at present over the families *Mustelidæ*, *Viverridæ*, *Cryptoproctidæ* and others, with five toes on all the feet, we reach those in which the hind foot has lost a digit, leaving the number 5—4. These are the *Protelidæ*, *Canidæ* and *Felidæ*. We can take but one step further in this order, that is, to those species where the anterior foot has also lost a toe, which constitute the family *Hyænidæ*. The toes are therefore here 4—4. For the well-marked characters of the three families mentioned just before, I refer to another page, and proceed to define, briefly, the division which has been heretofore termed the *Felidæ*. In doing so I am compelled to omit several of the characters generally employed

[1] See Homologies and Origin of Types of Molar Teeth of *Mammalia educabilia*. Journal Academy Phila., 1874, March.

to define that family, since I have found them to be wanting from various extinct genera. The only comprehensive definition which I can give is the following:

Digits 5—4. Sectorial teeth well developed in both jaws; not more than one true molar tooth in the upper, nor more than two true molar teeth in the lower jaw. Glenoid cavity grasping mandibular condyle anteriorly as well as posteriorly.

Prof. Gill, who has devoted much attention to the definition of the families of the *Mammalia*,[1] gives the following skeletal characters in his diagnoses of the *Felidæ* and of the three comprehensive divisions within which he places it. "I. Skull with the paroccipital process applied closely to the auditory bulla; the mastoid process small or obsolete; external auditory meatus very short or imperfect. Div. A. Carotid canal minute and superficial or obsolete; condyloid foramen and foramen lacerumposticum debouching into a common fossa; glenoid foramen minute or null. Os peuis rudimentary. Subdiv. 1. Otic bulla divided by a septum into posterior and anterior chambers communicating by a narrow aperture (Flower). Subdiv. a. Skull with no alisphenoid canal." All of the parts here mentioned I have found to be important in the definition of the natural divisions of the *Carnivora*, excepting those derived from the paroccipital and mastoid processes. But their condition in the extinct *Carnivora* which have been hitherto arranged with the *Felidæ*, and which resemble them very much in superficial characters, does not coincide with Prof. Gill's definition. Thus in the various American genera which resemble *Drepanodon*, the carotid canal is distinct from the *foramen lacerum posterius*, and the condyloid foramen is also separated from it by quite a space. These are characters which belong to most of the *Carnivora* with five digits on all the feet. Further, the postglenoid and postparietal foramina are present, also characters of the lowest *Carnivora*, as the bears and certain extinct dogs. Then there is an alisphenoid canal, which is also found in bears, dogs and the cat-like *Cryptoprocta*. I cannot demonstrate that the otic bulla is divided as the above diagnosis requires, in any of the fossil species. I have verified the above characters on species of the following genera, of which I have well preserved skulls; *Archælurus*, *Nimravus*, *Dinictis*, *Pogonodon*,[2]

[1] Arrangement of the Families of Mammals. Smithson. Miscell. Coll., 230, 1872, p. 56.

[2] Except those of the base of the skull.

and *Hoplophoneus*. Three genera, as yet only found in Europe, are similar in general characters, and probably agree with them. I allude to *Procælurus* Filh., *Ælurogale* Filh., and *Eusmilus* Gerv. On the other hand, the genus *Smilodon*, which includes the American sabre-tooths of Pliocene age, agrees with the true cats in the points in question; *i. e.*, the alisphenoid, postglenoid and postparietal foramina are wanting; the carotid foramen is either internal or wanting, and the condylar enters the jugular foramen at its mouth. This surprising condition of affairs makes it important to learn the characters to be found in the species of the longest known genus, *Drepanodon*, of the European beds. But although there are several good crania in European museums, I can find no description of their minute characters, and no mention made of their foramina. The probabilities are, on various grounds, that this genus agrees with *Smilodon* in the latter characters. The reasons in favor of this supposition are, the agreement in special dental characters, and the Pliocene age of the typical species, *D. cultridens*. Whether the Miocene species of Sansan and Epplesheim agree with this one in structure, is of course uncertain.

Seven and perhaps eight genera then, constitute a group to be distinguished from the true *Felidæ*, and, as it appears to me, as a distinct family. Should we ignore the characters adduced in this instance, we abandon at the same time the definitions of several of the other families of the order, and in fact, throw the system into confusion. I have proposed to call this family the *Nimravidæ*, and have contrasted it with the *Felidæ* in the following definition. Both are included n the division already defined on a preceding page.

No distinct carotid foramen nor alisphenoid canal; condylar foramen entering the foramen lacerum posterius. No postparietal, and generally no post glenoid foramina; *Felidæ*.

Carotid and condylar foramina entirely distinct from the foramen lacerum posterius; an alisphenoid canal, and post glenoid and postparietal foramina; *Nimravidæ*.

NIMRAVIDÆ.

The dental characters of the *Nimravidæ* are in general those of the *Felidæ*, the higher genera having the same dental formula.

Descending the scale the number of molar teeth increases at both ends of the series in the lower jaw, and anteriorly only in the upper, the number of the true molars never exceeding $\frac{1}{2}$. The following table gives the definitions of the genera. I am unfortunately ignorant of the characters of the foramina in *Proælurus* and *Pseudælurus*, as well as in *Ælurogale* and *Eusmilus*.

I. Lateral and anterior faces of mandible continuous; no inferior flange.

a. No anterior basal lobe of superior sectorial; inferior sectorial with a heel; canines smooth.

Molars $\frac{4}{4}\ \frac{1}{2}$; inferior sectorial with interior tubercle.....*Proælurus*.
Molars $\frac{3}{3}\ \frac{1}{1}$; inferior sectorial without interior tubercle.....*Pseudælurus*.

II. Lateral and anterior faces of mandibles separated by a vertical angle; no inferior flange; incisors obspatulate.

a. No anterior basal lobe of superior sectorial; inferior sectorial with a heel (and no internal tubercle); incisors truncate.

Molars $\frac{4}{3}\ \frac{1}{2}$; canine smooth.....*Archælurus*.
Molars $\frac{3}{3}\ \frac{1}{2}$; canine denticulate.....*Ælurogale*.
Molars $\frac{3}{2}\ \frac{1}{2}$; canine denticulate.....*Nimravus*.

III. Lateral and anterior faces of mandible separated by a vertical angle; an inferior flange; incisors conic, canines denticulate.[1]

a. No or a small anterior basal lobe of superior sectorial;[2] inferior sectorial with a heel. No posterior lobes of the crowns of the premolars.

Molars $\frac{3}{3}\ \frac{1}{2}$.....*Dinictis*.
Molars $\frac{3}{3}\ \frac{1}{1}$.....*Pogonodon*.
Molars $\frac{2-3}{2}\ \frac{1}{1}$.....*Hoplophoneus*.
Molars $\frac{?}{1}\ \frac{?}{1}$.....*Eusmilus*.

It is readily perceived that the genera above enumerated form an unusually simple series, representing stages in the following modifications of parts: (1) In the reduced number of molar teeth. (2) In the enlarged size of the superior canine teeth. (3) In the diminished size of the inferior canine teeth. (4) In the conic form of the crowns of the incisors. (5) In the addition of a cutting lobe to the anterior base of the superior sectorial tooth. (6) In the obliteration of the inner tubercle of the lower sectorial; and (7) in the extinction of the heel of the same. (8) In the development of an inferior flange and lateroanterior angle of the

[1] Gervais' figures of the canines of *Eusmilus bidentatus* represent no denticulations, but the figure is not clear.

[2] Rudimental in *Hoplophoneus*.

front of the ramus of the lower jaw. (9) In the development of cutting lobes on the posterior borders of the larger premolar teeth.

FIG. 1.—*Proælurus julieni* Filh.; two-thirds nat. size. From Filhol.

(1) The reduction in the number of molar teeth. The dental formula of *Proælurus* is that of some *Viverridæ* and *Canidæ*, and the reduction from this point to the end of the series is obvious. In *Eusmilus*, as in *Smilodon*, the number of molars is less by one in the inferior series, than in *Lynx* and *Neofelis*, where the formula is the smallest known among *Felidæ* proper, viz: $\frac{2}{2}\ \frac{1}{1}$. (2) The enlarged size of the superior canine teeth. In *Proælurus* and *Pseudælurus*, the canines of both jaws are subequally developed as in recent *Felidæ*. In *Archælurus* the superior is the larger, but does not, relatively to the molars, exceed that of *Felis*. It is rather compressed in form, and has a sharp cutting edge posteriorly. In *Nimravus* the superior canine begins to have the enlarged size of the sabre-tooths, but its form is peculiar in the *N. gomphodus*, being spike-shaped rather than sabre-shaped. We find the true sabre-shape first in *Dinictis*, where it is compressed, and with a denticulate cutting edge on both front and rear. In *Pogonodon* it has reached a very large size, and it does not display much increase in this respect until we reach the last genus of the series,

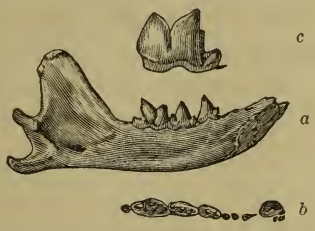


FIG. 2.—*Proælurus julieni* Filh.; two-thirds nat. size; *a* inner view of mandible; *b* superior view of inferior teeth; *c* inferior sectorial, natural size. From Filhol.

Eusmilus, where its proportions are enormous; almost as large as in the feline genus *Smilodon*, where they appear to have been an inconvenience to the animal. (3) The diminished size of the inferior canines becomes evident in the lower genera of the third division (supra) of the *Nimravidæ*, but is most decided in the highest genera *Hoplophoneus* and *Eusmilus*. (4) The incisor teeth have the usual obspatulate or obovate outline in the genera of the first and second divisions of the family, including *Nimravus*. They are conic in the true sabre-tooths with flared lower jaw, beginning with *Dinictis* and ending with *Eusmilus*. (5, 6 and 7) The structure of the sectorials. The presence of a heel and an inner tubercle of the lower sectorial are well known characters of a majority of the *Carnivora*. In only the most highly organized genera are they wanting, and among them are included all those of the *Felidæ* that still exist. In the *Nimravidæ* the inferior genera have both in a reduced degree, and they soon disappear as we ascend the scale. Thus the inner tubercle is only present in the species of *Procælurus*, *Dinictis* and *Hoplophoneus*. The heel on the other hand remains throughout the entire family. The anterior basal lobe of the superior sectorial has the same history, its absence being characteristic of the inferior *Carnivora*, and of all the genera of *Nimravidæ*, except in *Hoplophoneus*, where it is rudimental. It is well developed in *Drepanodon*, as in recent *Felidæ*, and is double in *Smilodon neogaeus*. (8) The development of the inferior flange and lateroanterior angle of the mandibular ramus. There is a successive advance in the development of these characters, beginning with the second group, for in the first they are wanting. The lateroanterior angle is developed in *Archælurus* and allied genera, and is merely continued on the inferior border of the ramus. In the third group it is much more acute, and is deflected downwards, forming the well known flange of the sabre-tooths. It is longest in the *Eusmilus bidentatus* Filh. (9) The highest genera of *Nimravidæ*, e. g. *Hoplophoneus*, differ from the true *Felidæ*, in the absence of the cutting lobes on the posterior edges of the crowns of the larger premolar teeth. But according to Filhol these lobes are present in the generalized genera, *Procælurus* and *Pseudælurus*, which are thus brought into a relation with the *Felidæ*, not possessed by other *Nimravidæ*.

A characteristic perfection of the *Felidæ* is seen in the genus *Smilodon*; that is, the vertical direction of the ungual phalanges, by

which the claws become retractile. This is well displayed by the two splendid specimens of *Smilodon necator* from Buenos Ayres, which have been preserved (See Fig. 12). Unfortunately, these phalanges have not yet been discovered in any species or the *Nimravidæ*, and it is not yet certain what their structure really was. Among the true *Felidæ*, the genus *Cynælurus* displays a less degree of development in this respect than the other genera, the ungual phalanges lacking the proximal process below the articular facet. Such a condition is to be looked for among the less perfect genera of *Nimravidæ*.

The succession of genera above pointed out coincides with the order of geologic time very nearly. Those belonging to groups first and second, belong to the lower and middle Miocene, except *Ælurogale*, which is perhaps upper Eocene, and *Pseudælurus*, which is middle Miocene. The genera of the first group of division third, have the same lower Miocene age, except *Eusmilus*, which has been found in the same formation (Phosphorites) as the *Ælurogale*.

The relations of these genera are very close, as they differ in many cases by the addition or subtraction of a single tooth from each dental series. These characters are not even always constant in the same species, so that the evidence of descent, so far as the genera are concerned, is conclusive. No fuller genealogical series exists than that which I have discovered among the extinct cats.

As to the phylogeny of this family, there are flesh-eaters of the Eocene period which may well have been the ancestors of both the *Nimravidæ* and *Felidæ*.[1] I have suggested that this position is most appropriately held by the *Oxyænidæ*, a family of several genera, which included the most formidable rapacious mammals of that early period in both continents. The interval between them and the *Nimravidæ* is however great, for in the *Oxyænidæ* when there is a sectorial tooth of the upper jaw, the first true molar is utilized instead of the last premolar; and the second true molar below is a sectorial as well as the first. Several intervening forms must yet be found to complete the connection, if it have ever existed. It is, however, very likely that the true *Felidæ* were derived from the genus *Procælurus* through *Pseudælurus*, if indeed these two genera be not the primitive members of that family, for as above

[1] See, On the genera of the *Creodonta*, by E. D. Cope, Proceed. Amer. Philos. Soc. July, 1880.

remarked, the evidence of their possession of the characters of the *Nimravidæ* has not yet been obtained. There can be no reasonable doubt that the genera *Drepanodon* and *Smilodon* in the *Felidæ* are the descendants of *Hoplophoneus* and allied genera. In fact, the *Nimravidæ* and *Felidæ* are "homologous groups," having corresponding terms in the manner I foreshadowed as a general principle in 1868 (Origin of Genera).

In looking for causes in explanation of the modifications of structure cited, one can easily discover that there is a close relation between the arrangement of the teeth and the mechanical laws involved in the performance of their function, those of seizing an active prey, and of cutting up their carcasses into pieces suitable for swallowing. It is obvious that in the latter case the flesh teeth bear the resistance, and the masseter muscle is the power, and that the nearer these parts are together, the better is the function performed. As a matter of fact, the sectorial teeth in modern carnivora are placed exactly at the angle of the mouth, which is the front border of the masseter muscle.

In the process of evolution both the muscle and the teeth have moved forwards in connection with the shortening of the jaw behind. This has been due to the necessity of bringing the power (masseter) nearer to another point of resistance, viz: the canine teeth.

In the early carnivores (as Hyænodontidæ) the long jaws supported more numerous teeth ($\frac{4-3}{4-3}$) than in any modern families, and the fissure of the mouth was probably very wide, as the last molar was a sectorial. The canine teeth were evidently very ineffective weapons. The animals probably only snapped with their jaws, and did not attempt to lacerate or hold on, as do the cats.

The dogs of to-day are long jawed, and they snap in a manner quite distinct from anything seen among the cats. The only dogs that hold on are the short jawed bull-dogs.

So in the use of the canines we have the ground of the shortening of the jaw behind and before, and the consequent change of structure which resulted in the modern perfected *Felidæ*.[1]

The following list shows the number and distribution of the species of the *Nimravidæ*:

[1] See AMERICAN NATURALIST, 1878, p. 171.

	Upper Eocene.	Lower Miocene.		Upper Miocene.		Pliocene.	
	Eur.	Eur.	Am.	Eur.	Am.	Asia. Eur.	Am.
Proælurus julieni Filh		×					
" lemanensis Filh		×					
Pseudælurus hyænoides Blv			×				
" edvardsi Filh	×						
" intrepidus Leidy					×		
" sivalensis Lydd						×	
Archælurus debilis Cope			×				
Ælurogale intermedia Filh	×						
" "acutata Filh." [1]							
Nimravus gomphodus Cope			×				
" confertus Cope			×				
Dinictis felina Leidy			×				
" cyclops Cope			×				
" squalidens Cope			×				
Pogonodon platycopis Cope			×				
" brachyops Cope			×				
Hoplophoneus oreodontis Cope			×				
" primævus Leidy			×				
" occidentalis Leidy			×				
" cerebralis Cope			×				
Eusmilus bidentatus Filh	×						

We may now consider in more detail the characters of the genera and species of North America.

Division I. The Primitive Cats.

PSEUDÆLURUS Gervais. Although this genus commences in the Phosphorites of France, which are generally referred to the upper Eocene, it has at least some dental characters of the true *Felidæ*. Even at that early period, if well defined period, it be,[2] the premolar teeth are lobed; see *P. edvardsi* Filhol. The single American species, the *P. intrepidus* Leidy is from a late Miocene formation, the Loup Fork. It is only known from lower jaws, of which Dr. Hayden procured one in Nebraska, and the writer another in Colorado. It was a species with large teeth, of about the size of the Canada lynx.

Division II. The False Sabre-tooths.

ARCHÆLURUS Cope.

This genus is of interest as completing the connection between the sabre-tooth and primitive unspecialized groups of the cats, a transition also clearly indicated by the genus *Nimravus*. In den-

[1] I only know this species by name.

[2] The Phosphorites are suspected by some to contain mixed materials from different horizons.

tition it adds a tooth to the number belonging to that genus, in both jaws, and has a smooth-edged canine; it is otherwise identical with that genus, unless, indeed, the exostosis supporting the inferior sectorial tooth in the *A. debilis*, be introduced into this category; a position I am not prepared to assume positively. There is but one species known, the

Archælurus debilis Cope.

It is probable that this was an animal presenting much the appearance of the existing cats, and of about the size of the American panther. Omitting more technical characters, it differed from this and other species of the *Felidæ* in the greater slenderness of its feet. Its head was characterized by less breadth through the posterior part of the cheeks, and by a greater convexity of the forehead between the eyes, and a greater prolongation backwards of the same region.

Its structure plainly indicates that this species was of less sanguinary habits than the existing *Felidæ*, since its prehensile organs, both of the feet and dentition, are less robust. The slender zygomata and rami of the lower jaw show also that the impact of its bite was less powerful, although the large size and narrow form of the sectorial teeth, furnish an effective cutting apparatus, which in some degree supplements the deficiency of strength. The weakness of the rami is further provided against

FIG. 3.—*Archælurus debilis*, one-half natural size. Mus. Cope. From Vol. IV, Report of U. S. Geol. Surv. Terrs.

by the curious exostosis at the base of the inferior sectorial, already mentioned; see Fig. 3.

The first description of this species was given by myself under the head of the *Nimravus brachyops (Machærodus brachyops.* Palæontol. Bulletin, 30, p. 10, Dec., 1878), from a skull found by

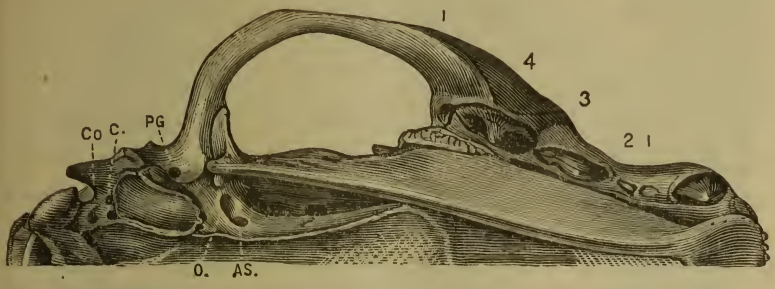


FIG. 4.—*Archælurus debilis*, one-half nat. size; inferior aspect of Fig. 1. Foramina: AS, alisphenoid; O, ovale; PG, postglenoid; C, carotid; Co, condylar.

Mr. Sternberg, under the impression that it might belong to a female of that species. Subsequently a nearly perfect cranium. obtained by Mr. Wortman, demonstrated the distinctness of the animal both as to species and genus.

Horizon and Locality. The remains of the *Archælurus debilis* have so far been only found in the Truckee Miocene formation of the John Day river, Central Oregon. Judging from the remains, it was, after the *Nimravus gomphodus* the most abundant feline of that region.

NIMRAVUS Cope.

This genus has the dental formula and characters of *Hoplophoneus*, with the addition of a tubercular inferior molar tooth. It is, moreover, not a true sabre-tooth, as is that genus, since it does not display the inferior anterior flange of the mandible. This is represented by an obtuse angular border, quite as in the species of *Archælurus*, in which genus *Nimravus* finds its nearest ally. The constant absence of the anterior premolars in both jaws distinguishes it sufficiently from that genus. On this account, and in view of the larger development and denticulated edge of the superior canine teeth, *Nimravus* may be considered as occupying a position between the two genera above named.

Two species are known to me, a larger and a smaller, both from the Middle Miocene formation.

Nimravus gomphodus Cope.

The *Nimravus gomphodus* is as large as the full-grown panther of the large varieties. It probably stood as high above the ground, but whether the body had the elongate proportions of that animal, or the more robust form of the leopard and jaguar, cannot be ascertained in the absence of necessary material. Unless the animal had pendulous upper lips, a thing unknown among cats, the superior canine teeth must have been distinctly displayed on each side of the chin; their points descending entirely below the lower margin of the lower jaw, when the mouth is closed. As these points are less compressed than in the true sabre-tooths, they were less liable to fracture from lateral blows, but were more apt to be broken by fore-and-aft strains, owing to their slenderness.

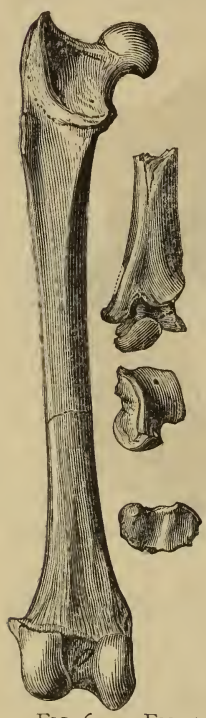


Fig. 6. Fig. 5.

Fig. 5.—End of tibia and astragalus of *Archælurus debilis*. Fig. 6.—Femur of *Nimravus gomphodus*. All one-third natural size. Mus. Cope.

The long canines of this species testify to blood-thirsty habits, for as weapons for penetrating wounds they are without rival among carnivorous animals. They resemble considerably the teeth of some of the *Dinosauria*, for instance, those of the Triassic *Clepsysaurus*. The sectorial apparatus is especially effective, and no tissue could long resist the combined action of the opposing blades of the two jaws. Nevertheless this species did not, probably, attack the large *Merycochœri* of the Oregon herbivores, for their superior size and powerful tusks would generally enable them to resist an enemy of the size of this species. They were left for the two species of *Pogonodon*, who doubtless held the field in Oregon against all rivals. The compressed mandibular rami of the *Nimravus gomphodus*, though less slender than those of the *Archælurus debilis*, are not so well calculated to resist lateral strains as the more robust jaws of the majority of the existing *Felidæ*.

Nimravus confertus Cope.

Although a left mandibular ramus is all that I have been able to obtain of this cat, the evidence is sufficient that it is specifi-

cally different from the others enumerated in this chapter. It is inferior in size, and peculiar in the reduced symphyseal and in-

Fig. 7.—*Nimravus gomphodus*, two-fifths natural size. Mus. Cope. From Vol. IV, U. S. Geol. Surv. Terrs.

cisive parts of the mandible. It was found by Mr. Wortman in the bad-lands of the John Day valley, Oregon.

Division III. The Primitive Sabre-tooths.

DINICTIS Leidy.

With this genus we enter the group of the primitive sabre-tooths, commencing with the most generalized form. The skeleton is yet unknown, but the skull and dentition are those of a true sabre-tooth, and there seems to be no ground for believing the Musteline affinities suggested by Leidy.[1] It occupies the lowest position on the line of the sabre-tooths, on account of its numerous and simply constructed molar teeth, and stands in immediate connection with the false sabre-tooth group, having exactly the dental formula of *Ælurogale* Filh. On this account I formerly united the two genera, but now believe that the absence of the inferior flange of the mandible in *Ælurogale* is sufficient ground for maintaining them as distinct. The latter genus, in this respect, exactly resembles *Archælurus* and *Nimravus*.

Remains of this genus are quite abundant in the White River

[1] Extinct Mammalia, Dak., Nebr., p. 64.

formation in Nebraska and Colorado. They principally belong to the longest known and typical species, *D. felina* Leidy. Specimens are much less numerous in the Truckee beds of Oregon. Two species have been obtained from the former horizon, the *D. felina* and *D. squalidens*, and one from the latter, the *D. cyclops*.

Dinictis cyclops Cope.

This cat is represented by a perfect cranium with its mandible, which lacks only the posterior portions. The dentition is com-

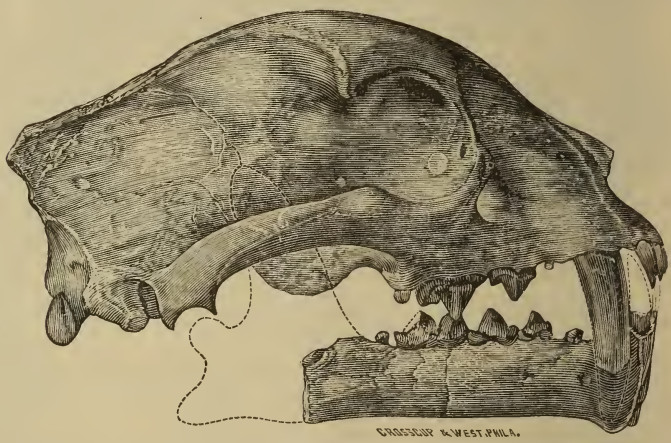


FIG. 8.—*Dinictis cyclops*, one-half natural size. Mus. Cope. From Vol. IV, U. S. Geol. Surv. Terrs.

plete, excepting the posterior parts of the two inferior sectorials, and the apices of the canines and incisors. The condition of the specimen allows its characters to be seen with clearness. The species was as large as the fully grown Canada lynx. Although of an inferior position in the system of *Carnivora*, its powers of destruction must have excelled those of the catamount. While the skull is generally less robust, its sectorial teeth are not smaller nor less effective than those of that animal, and the canines far excel those of the living species, as instruments for cutting their prey.

Dinictis felina Leidy.

This species is known from a number of crania and jaws. The former differ in their proportions from those of the *D. cyclops*, having a relatively longer cerebral and shorter facial part of the skull. The anterior premolar teeth, especially in the upper jaw, were stronger than those of *D. cyclops*.

Dinictis squalidens.

In this species the first lower molar tooth has but one root, while in the others there are two. The canine tooth of the typical specimen has also a very peculiar form. The crown is short and wide like that of a *Carcharodon* shark, or somewhat like that of the sabre-tooth *Drepanodon latidens* Owen. As the first true molar tooth of this specimen was not fully protruded, it is possible that this canine belongs to the deciduous series.

As the tubercular tooth of the specimen on which this species was established could not be found in the jaw, I proposed to regard the species as typical of a genus distinct from *Dinictis*, remarking at the time that should such a tooth be ultimately found, the genus would have to be abandoned. Evidence of the existence of this tooth was afterwards obtained. Still later, another sabre-tooth was found with precisely the formula supposed to characterize this discarded genus (*Daptophilus*). Under the circumstances I thought best to give the former a new name, *Pogonodon*.

Pogonodon Cope.

This genus represents a station on the line connecting *Dinictis* with the higher sabre-tooths, being intermediate between the former genus and *Hoplophoneus*. It lacks the tubercular inferior molar of *Dinictis*, and possesses the second inferior premolar characteristic of that genus, which is wanting in *Hoplophoneus*. One species is certainly known, and a second is provisionally referred here. The two are the largest of the sabre-tooths of North America, the type *B. platycopis* equaling in dimensions the largest species of *Drepanodon*, being only exceeded among the true sabre-tooths by the species of *Smilodon*. Unfortunately only the skull of the typical species is known. Several bones of the *P. brachyops* have been discovered.

Pogonodon platycopis Cope.

As the greater part of the skeleton of the *Pogonodon platycopis* is unknown, little can be said as to its general proportions. The skull is one-sixth shorter than that of the usual size of the tiger (*Uncia tigris*), and is equal to the largest Brazilian variety of the jaguar, and is considerably larger than the Texan form of that species.

The development of the dentition is concentrated in the canine teeth, and the powers of destruction of the animal would seem to

be disproportioned to its ability to appropriate its prey as food. The molar teeth are rather small, as is the case with the earliest

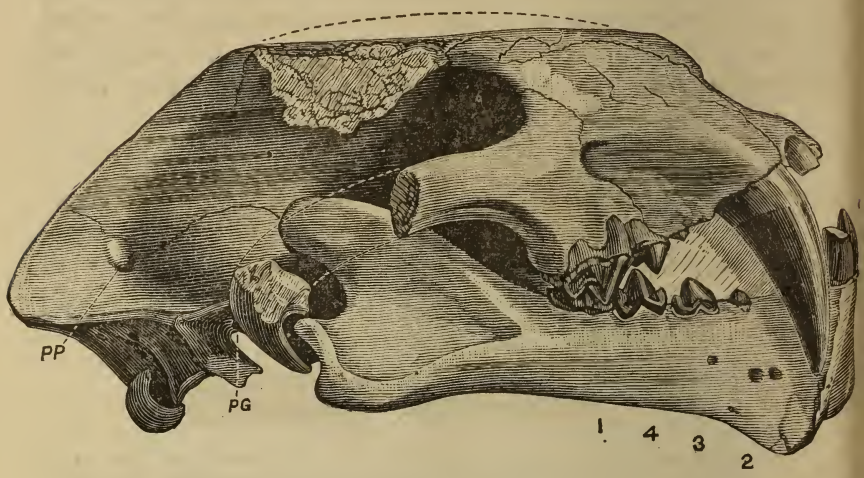


FIG. 9.—*Pogondon platycopis*, less than two-fifths natural size. Mus. Cope. From Vol. IV, U. S. Geol. Surv. Terrs.

representatives of the canine family. The inferior sectorial is primitive and peculiar in its robust heel. We can suppose this species to have been a great destroyer of contemporary mammalian life, and that the largest ungulates of the Truckee fauna were its victims.

History. Science has hitherto had little knowledge of this species, and owes what is here recorded to a fortunate chance. The exploring party which I had sent into the John Day River valley under the direction of Mr. Jacob L. Wortman, in 1879, examined the bad-lands in the locality known as The Cove. In passing the bluffs on one occasion, a member of the party saw on the summit of a pinnacle of the crag what appeared to be a skull. The large shining objects supposed to be teeth attracted his attention, and he resolved to obtain the specimen. He, however, was unable to climb the cliff, and returning to camp narrated the circumstance. The other men of the party successively attempted to reach the object, but were compelled to descend without it, and in one case, at least, the return was made at considerable peril. A later attempt, made by Leander S. Davis, of the party, an experienced collector, was more successful. By cutting notches with a pick, in the face of the rock, he scaled the pinnacle and brought down the skull, but at considerable risk to limb and life.

Pogonodon brachyops Cope.

This was a most formidable animal, and its dental characters indicate a high degree of efficiency of both the lacerative and of the biting functions. While the *P. platycopis* has a larger development of the canine teeth, it is inferior in the relative size of

FIG. 11.

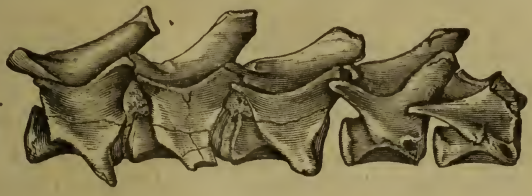


FIG. 10.

FIG. 10.—Lower jaw of *Nimravus confertus*, one-third natural size. FIG. 11.—Dorsal and lumbar vertebræ of *Pogonodon brachyops*, one-third natural size. Mus.Cope. From Vol. IV, U. S. Geol. Surv. Terrs.

the sectorials. In the latter respect the *P. brachyops* resembles the species of *Nimravus* and *Archælurus*, but these are furnished with smaller or more slender canines. It, however, resembled the latter in having the feet relatively smaller than in the recent cats, a character which indicates inferior prehensile power. Unfortunately no ungual phalanges have been preserved, so that we cannot learn whether they confirmed this indication by resembling those of the *Cynælurus jubatus* or the still less specialized forms of other families.

History. This species was the first of the Oregon felines of which bones were obtained. It was first sent here by Mr. C. H. Sternberg from the Truckee Miocene bad-lands of the John Day valley, Oregon. Although I do not possess a mandible, I am satisfied that it is more nearly allied to *Dinictis* and the present genus than to *Nimravus*. It differs from the species of that genus and *Archælurus* in the following points: (1) the truncate triangular posttympanic process; (2) the transverse frontomaxillary suture; (3) the preorbital impressed depression; (4) the superior position of the postparietal foramen.

HOPLOPHONEUS Cope.

In this genus we reach the dental formula of *Drepanodon* and the true cats, while at the same time the primitive form of the

sectorials of the lower jaw remains. Three or four species only are known as yet, all from North America. We may expect, however, to find the genus in various parts of the world, wherever the beds occur which represent the time immediately preceding the epoch of the true sabre-tooths. The longest known species is the

Hoplophoneus primævus Leidy, from the White River bad-lands of Dakota and Nebraska. It is about as large as the Canada lynx, and has long and slender superior canines. A larger species, the *H. occidentalis* Leidy, from the same horizon and locality, is known from a single jaw fragment, as large as the corresponding part of the *Nimravus gomphodus*. Although the oldest members of the *Nimravidæ* yet known from North America, the *Drepanodon* characters of the mandible and of the superior canine tooth are well developed, much more so than in the false sabre-tooth group of the later Truckee epoch. In Europe, however, it must be remembered that the latter division commences still earlier, in the Upper Eocene, in the genus *Ælurogale* Filhol.

Hoplophoneus oreodontis Cope.

This species is nearly allied to the *Hoplophoneus primævus*, of which it may be only a regional variety. It is distinguished by its shorter and wider face and palate, a character especially seen in the shortness of the diastema, which is considerably less than in the Nebraska species. With this animal it compares much as the bull-dog does with the ordinary varieties of the genus *Canis*.

The two specimens I have described were found by myself on a denuded portion of the White River formation in Northeastern Colorado. At the same locality were multitudes of bones, mostly jaws, of fifty species of various orders of *Mammalia* and *Reptilia*, on many of which it doubtless preyed.

Hoplophoneus cerebralis Cope.

This peculiar species, the smallest of the genus, approaches nearest in dentition to the true sabre-tooths *(Drepanodon)*, and is represented by a skull, from which the basioccipital region, a good deal of the right side, and the lower jaw are absent. It differs in many respects from all the members of this family of cats heretofore discovered in North America. In almost every point in the osteology of the skull it is peculiar. There is not as much space for the temporal muscle as in most of the extinct

species described, or as in the large recent *Unciæ*, but the points of origin of the muscle indicate that it was relatively stronger than in the domestic cat and the lynxes. Its single premolar is very small, so that the dentition for practical use is reduced, in the upper jaw, to the canine and sectorial. Both have been most effective instruments in the performance of their respective functions. The sectorial has a distinct anterior basal lobe. The space for the accommodation of the brain is relatively more ample than in any other feline of the formation, and the inner wall indicates that the convolutions of the hemispheres were well developed. This species, if the cranium were of usual proportions, was about the size of the red lynx *(Lynx rufus)*.

The unique specimen of this species was found by Mr. J. L. Wortman in the bad-lands of Camp creek, one of the head tributaries of the Crooked river, in Central Oregon.

Hoplophoneus strigidens Cope.

Represented only by a part of a canine tooth. This tooth belonged to an animal of about the size of the *H. cerebralis*, and perhaps to that species. If so, it indicates for it a longer canine than usual, as its extremely compressed form points to a position at a considerable distance beyond the base of the crown. The probabilities are against reference to the *D. cerebralis*.

The tooth is the most elegant in form and perfect in its details yet found. As a cutting instrument it is superior to anything of human manufacture which I have seen.

Found by C. H. Sternberg on the John Day river, Oregon, in the Truckee beds.

Felidæ.

As defined in the preceding pages, the family of the true cats is of comparatively modern origin. We know that they existed during the Pliocene epoch, and it is very probable that they have been found in the Upper, and perhaps in Europe, in the Middle Miocene. If *Pseudælurus* and *Proælurus* pertain to it, the family dates from the Upper Eocene (Phosphorites).

Like the *Nimravidæ*, the *Felidæ* has its sabre-tooth division, with the long superior canine, reduced inferior canine, and flared lower jaw already described. In both divisions species are known which exceed in size any of those of the older family which have yet come to light. Such animals constitute the most formidable type of Carnivorous *Mammalia*.

The classification of the family is as follows:

I. The anterior and lateral faces of the mandible separated by an angle.

a. Inferior border of mandible flared downwards in front.

β. Inferior sectorial without heel; an anterior lobe of the superior sectorial, and posterior lobes of the premolars.

Premolars $\frac{3}{3}$, first inferior two-rooted.....*Drepanodon*.
Premolars $\frac{2}{2 \text{ or } 1}$; first inferior one-rooted.....*Smilodon*.

II. The anterior and lateral faces of the mandible continuous, convex. (No inferior tubercular molar.)

α. Inferior sectorial without heel; premolars with posterior lobes; superior sectorial with anterior lobe.

β. Superior sectorial without internal heel; ungual phalanges without inferior process.

Pupil round, premolars $\frac{3}{3}$; orbit open posteriorly.....*Cynælurus*.

ββ. Superior sectorial with internal heel; ungual phalanges with inferior process.

γ. Pupil round.

Premolars $\frac{3}{3}$.....*Uncia*.
Premolars $\frac{1}{1}$.....*Neofelis*.

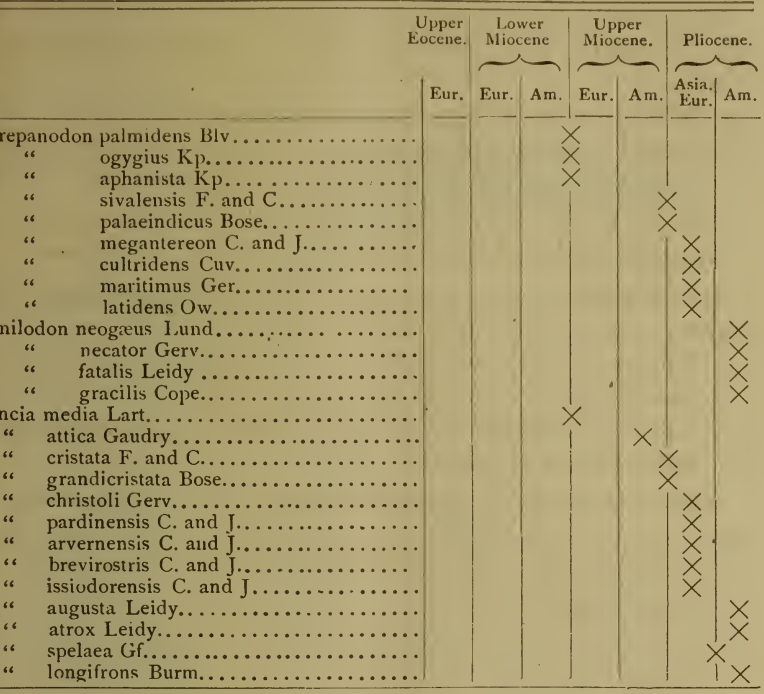
γγ. Pupil vertical.

Orbit closed behind; premolars $\frac{3}{3}$.....*Catolynx*.
Orbit open; premolars $\frac{3}{3}$.....*Felis*.
Orbit open; premolars $\frac{1}{1}$.....*Lynx*.

The tendency to reduction of the number of molar teeth is seen in the above genera, as already pointed out in the *Nimravidæ*.

The only extinct genera are *Drepanodon* and *Smilodon*. Of the other genera the greater number of extinct species belong to *Uncia*.

The following catalogue of species and their distribution shows that but few of the extinct *Felidæ* have yet been found in North America. A star on a line between two columns shows an intermediate stratigraphical position. The extinct true cats whose crania have been discovered, belong to *Uncia*, but it is possible that some of the European species, which are as yet only known from lower jaws, may be species of the genus *Felis* or *Lynx*.



As already remarked, the genera of the Nimravine and Drepanodont lines are extinct, and this in spite of the fact that they presented the most perfect weapons of destruction in their canine teeth, from the earliest times. Their other modifications of structure advanced, *pari passu*, with those of the feline series, and, among others, the feet presented in the latter forms at least (*e. g.*, *Smilodon necator*, Gerv.), the most perfect prehensile power of the lions and tigers of to-day. As nothing but the characters of the canine teeth distinguished these from the typical felines, it is to these that we must look for the cause of their failure to continue. Prof. Flower's suggestion appears to be a good one, viz: that the length of these teeth became an inconvenience and a hindrance to their possessors. I think there can be no doubt that the huge canines in the *Smilodons* must have prevented the biting off of flesh from large pieces, so as to greatly interfere with feeding, and to keep the animals in poor condition. The size of the canines is such as to prevent their use as cutting instruments, excepting with the mouth closed, for the latter could not have been opened sufficiently to allow any object to enter it from the front.

Even when it opens so far as to allow the mandible to pass behind the apices of the canines, there would appear to be some risk of the latter's becoming caught on the point of one or the other canine, and forced to remain open, causing early starvation. Such may have been the fate of the fine individual of the *S. neogæus*, Lund, whose skull was found in Brazil by Lund, and which is familiar to us through the figures of De Blainville, etc.

Drepanodon Nesti. (*Machærodus* Kaup).

This genus as understood by most authors, belongs to the later Miocene and Pliocene, and has had numerous representatives in Europe and Asia. No species has as yet been found in America. Some of the species described by authors are only known from fragments, so that much remains to be ascertained as to the prevalence among them of the characters I have assigned to the genus and family. Those given are derived from the two species best known, the *D. cultridens* and *D. megantereon*, which have been readily obtained from the descriptions and figures of authors.

It is difficult to ascertain the number of European species. Pomel's catalogue is generally cited, and this is, with some subtractions and additions, the basis of the list already given.

Smilodon Lund.

Besides the family characters already given, this genus differs from the *Nimravidæ* in two other important respects. In both points it differs also from such existing members of the *Felidæ* with which I have been able to compare it. In both *S. fatalis* and *S. necator*, the posttympanic process of the skull is coössified with the postglenoid, thus closing the auricular meatus below. It thus differs from other *Felidæ* as the genus *Rhinocerus* differs from various other members of *Rhinoceridæ*. The second point has been indicated by Prof. Gervais. There is no epitrochlear arterial canal, such as belongs to cats and *Nimravidæ* generally. This I have only verified on the *S. necator*.

This genus represents in America the Drepanodons of the Old World. The known species belong to the Pliocene period, and were the cotemporaries of the gigantic sloths and *Glyptodons*, which at that time ranged over the entire American continent. Their powerful limbs terminated by immense claws, bespeak for them exceptional force in striking and tearing their prey, and the long compressed canine teeth are well adapted for penetrating the

tough hides and muscles of the large Edentata, which were doubtless their food. There are known two species of large size from

FIG. 13.—*Smilodon necator* Gervais, one third natural size. Original. Mus. Cope.

the Pliocene of South America, and probably two species from North America. A figure of the skeleton of the *S. necator* Gervais accompanies this paper. It is a copy of a lithograph taken by Prof. Burmeister from a specimen in the Museum of Buenos Ayres. The second known skeleton, found by M. Larroque near to the village Areco, a few miles west of Buenos Ayres, is in possession of the writer. Lateral and inferior views

of the skull of this individual, one-third of the natural size, are represented in figures 13 and 14.

FIG. 14.—*Smilodon necator*, one-third natural size. Inferior view of skull Fig. 12.

This specimen is the one on which the late Prof. Gervais based his determination of the species (*Comptes Rendus*, 1878, June), but which he had not described at the time of his death. The species is about the size of the lion, and of the most formidable character.

A fragment of a maxillary bone containing a sectorial tooth found in Texas was referred to an extinct cat, by Prof. Leidy, under

the name of *Trucifelis fatalis*. As it possesses a second anterior basal lobe of the superior sectorial, it is doubtless a *Smilodon*. I am confirmed in this opinion by the characters presented by an important specimen sent me by G. W. Marnock, who obtained it in Southwestern Texas. It consists of that portion of a cranium, which is posterior to the orbits, and represents an animal of the size of the *S. necator*, or of a large tiger. The positions of the foramina and the conjunction of the posttympanic and postglenoid processes are as in the *S. necator*. When more of this species is known, it will doubtless be found to be our largest sabre-tooth.

Among the remains obtained by Charles M. Wheatley from a cave on the Schuylkill river, in Pennsylvania, which I described in 1871, there occurred a part of the canine of a sabre-tooth. Hoping to obtain better specimens, I did not include it in the published lists. Having established the existence of the genus *Smilodon* as a contemporary of the sloths during the Pliocene period in North America, it becomes probable that the species of the caves is also to be referred to it. The canine in question has lost most of its crown. It is of smaller size than that of either of the three species previously mentioned, and its basal portion is more compressed. This compression is a marked character, and I refer to it the name *Smilodon gracilis*, by which the species may be known.

FIG. 15. — *Smilodon necator;* humerus of specimen Figs. 12, 13, from front, one-third natural size. Mus. Cope.

UNCIA Gray (Cope emend.).

Extinct species of this genus have been found in the late Miocene and subsequent deposits in India, Europe and North America. It is distinguished from the

true *Felis* by the round form of its pupils. This can only be observed in the living species, so that some correlated index of it must be used in determining the genus from skulls. This Dr. Gray shows is seen in the small size of the orbits, which are always less than those of the species of *Felis*.

Fragmentary remains from the Loup Fork formation of Nebraska and the Pliocene and Quaternary of Mississippi and California have been described by Leidy under the names of *Felis augustus, F. atrox* and *F. imperialis*. Dr. Leidy suggests that there may have been two species, the one *(F. augustus)* characteristic of the Loup Fork epoch, and *F. atrox*, the second, belonging to a later period. The *Uncia augusta* was intermediate in size between the *U. onca* and the tiger, while the *Uncia atrox* was, according to Leidy, larger than the lion or tiger. It represents in America the *Uncia spelea* of the European caves, and should be carefully compared with that species.

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AUTHOR'S EDITION.

DEPARTMENT OF THE INTERIOR.
UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY.
F. V. HAYDEN, U. S. Geologist-in-Charge.

ON SOME NEW BATRACHIA AND REPTILIA FROM THE PERMIAN BEDS OF TEXAS;

ON A WADING BIRD FROM THE AMYZON SHALES;

ON THE NIMRAVIDÆ AND CANIDÆ OF THE MIOCENE PERIOD;

AND

ON THE VERTEBRATA OF THE WIND RIVER EOCENE BEDS OF WYOMING.

BY

E. D. COPE.

EXTRACTED FROM THE BULLETIN OF THE SURVEY, Vol. VI, No. 1.

WASHINGTON, February 11, 1881.

Art. II.—On some new Batrachia and Reptilia from the Permian Beds of Texas.

By E. D. Cope.

PANTYLUS CORDATUS gen. et sp. nov.

Char. gen.—Represented by one species, which is as yet only known from crania. In these the superficial ossification is complete, leaving only nostrils, orbits, and parietal fontanelle. Surface sculptured. Mandible with an angular process. Teeth shortly conic, obtuse, and without grooves or inflections, increasing in size towards the anterior parts of the jaws. Mandible supporting several rows of teeth, which oppose a pavement of obtuse teeth on the palate. These are situated on either the palatine or anterior part of the pterygoid bones. Quadratojugal and malar bones well developed. No lyra or mucous grooves.

This genus is first of the *Stegocephali* from the Permian formation of Texas, whose cranial structures indicate a habit of obtaining nutriment by crushing hard bodies. Without vertebræ it is not possible to ascertain whether it pertains to the Microsaurian, Embolomeran or Ganocephalous divisions. It may be compared with the *Sparodus* of Fritsch in the general characters of its dentition, but may be easily distinguished from it by the numerous series of teeth on the mandibular rami. Some of these are on the dentary bone, while others are on an inner element, but whether opercular or splenial I cannot now determine.

Char. specif.—The skull of the *Pantylus cordatus* is about as large as that of a fully grown snapping tortoise, *Chelydra serpentina*, and has somewhat the same form of outline. The vertex is flat; the postorbital region is swollen, and the muzzle is abruptly acuminate. The orbits are lateral with a slight vertical exposure, and are widely separated. The front is deflected from opposite their posterior margins, and the muzzle protrudes considerably beyond the lower jaw. The premaxillary bones form a triangle whose apex does not appear on the superior surface of the muzzle, and the nares are rather close together, and lateral in their vertical presentation. The upper surface of the extremity of the snout is occupied by the large nasal bones, which are followed by the larger frontals. The lachrymal and prefrontal are both well developed, the latter extending backwards to meet the postfrontal near the middle of the superior border of the orbit. The posterior border of the skull is damaged, but enough remains to show that it was concave.

The symphysis mandibuli is short. The rami are wide, and are flat below, the inferior surface forming a rounded right angle with the interior surface. The angular process is in line with the external border of the ramus.

The sculpture of the cranium proper is strong, consisting of pits separated by strong, narrow ridges, forming a honeycomb pattern. The fossæ are smaller on the buccal regions. On the anterior part of the mandible the fossæ are distinct; on the median and posterior part the ridges become linear. A narrow triangular space on the external side posteriorly, with its long apex on the inferior margin, is smooth.

There are two subequal obtuse teeth, on the border of each premaxillary bone. I cannot count the number on the maxillary, but there are four anterior to the line of the anterior border of the orbit. Of these the next to the anterior one is larger than the rest, though of the same shortly-conic, obtuse form. These teeth are rather large for the size of the skull. At a point near the middle of the ramus of the mandible, where it is broken off, there may be counted five teeth in a transverse series. Of these the second from the external border is the largest, and has a regularly rounded crown. Six teeth may be counted on a transverse fracture of the palatine bone. Of these the four external have obtusely rounded crowns, and the third from the external border is the largest. The crowns of all the teeth are hollow.

Measurements.

	M.
Length of cranium to transverse line connecting posterior borders of quadrates	.077
Width between same points	.082
Length of axis of cranium to line connecting anterior borders of orbits	.018
Interorbital width	.032
Longitudinal diameter of orbit	.016
Length from orbit to nostril	.015
Projection of muzzle beyond mandible	.010
Length of alveolar edge of premaxillary	.007
Height of crown of large maxillary tooth	.0045
Fore-and-aft diameter of maxillary	.0035
Width of mandibular ramus below at middle	.020

This species considerably exceeds in size those referred by Dr. Fritsch to *Sparodus*, as it was probably rather larger than the *Protonopsides* of recent waters. Its physiognomy is peculiar, as the prominent muzzle and lateral orbits are unusual among Batrachia.

DIMETRODON SEMIRADICATUS sp. nov.

A considerable part of the skull and some limb bones represent this species. There are no vertebræ referable to the specimen, but the two maxillary and premaxillary bones support nearly all the teeth in an excellent state of preservation. Continuity of the dental series is preserved by one maxillary bone or the other, excepting just at the extremity, where there is a slight interruption on both sides. On one of them it must be very slight.

There are three teeth in each premaxillary bone. In the maxillary I count seventeen, with the bare possibility of a necessity for adding one more. The first premaxillary and third maxillary teeth are of nearly equal size and are much larger than the others, the second premaxillary only approaching them. The section of the base of the first premaxillary is subtrifoliate, there being one grove on the inner, and two on the external face. The section of the middle of the crown is more than a semicircle, with the base convex. The two angles are the sections of two ridges which are both presented posteriorly, the one on the inner the other on the external face of the crown. The crown of the second premaxillary has the same form, but the base has only slight traces of the grooves. The third premaxillary is a diminutive of the second.

The crowns of the maxillary teeth differ from those of the premaxillaries in the opposition of the cutting edges, which present anteriorly and posteriorly. The external face is more convex than the internal. The crown of the large third tooth is not expanded above the root, but its antero-posterior diameter contracts regularly to the apex. The crowns of the other teeth are wider at the base antero-posteriorly than the root. They are all slightly curved backwards, and their edges are more or less regularly crenate.

Several peculiarities distinguish this species from the *D. incisivus*, with which it agrees in size. In the first place, the section of the root, at and below the base of the crown of the third or large maxillary tooth and of the seventh tooth posterior to it, is of the form of a figure ∞ directed antero-posteriorly. This is due to the deep grooving of the tooth on the opposite sides at this point; the grooves not extending on the crown. The grooves are deeper on the smaller teeth, giving it an almost biradiculate character. In *D. incisivus* the sections of these teeth are subquadrate.

In the second place, the section of the base of the first incisor differs from that in *D. incisivus*, where it is subquadrate with two subopposite shallow grooves. Next, the nostril excavates the border of the maxillary bone; in *D. incisivus*, the nostril is separated from that bone by the intervention of the nasal. In that species there are but two premaxillary teeth; in *D. semiradicatus*, there are three. The teeth which accompany specimens of *D. cruciger* have the same form and proportions as those of the *D. incisivus*.

Measurements.

		M.
Length of dental series		.252
Length of premaxillary series (and bone)		.049
Length of diastema		.024
Length of first premaxillary tooth from alveolar border		.057
Diameter of first premaxillary tooth at alveolar border	anteroposterior	.022
	transverse	.015
Length of third maxillary from alveolar border		.067
Diameter of third maxillary at alveolar border	anteroposterior	.020
	transverse	.005

		M.
Diameter of third maxillary at base of crown	anteroposterior	.01
	transverse	.01
Length of seventh maxillary from alveolus		.02
Diameters of crown at base of cutting edges	anteroposterior	.012
	transverse	.009

The approximation to a two-rooted condition in some of the teeth is a marked peculiarity of this species. The median groove is most extensive on the smaller maxillary tooth, extending into the base of the crown. From observation on this species and on certain *Dinosauria*, I am under the impression that the two-rooted mammalian tooth is the result of constant absorption of the median portion of the wide root of a wide crown, due to the presence and pressure of the successional tooth.

DIMETRODON CRUCIGER Cope, Paleontological Bulletin No. 32, p. 7.

This species was abundant during the Permian period. One of the best preserved individuals in my collection is represented by the greater part of the vertebral column and the pelvic and scapular arches.

The pelvic arch resembles that of the *D. gigas* in its general characters. For a description of the latter see Paleontological Bulletin No. 32, p. 6. The scapular arch also agrees with the descriptions I have given, but possesses some parts which have been hitherto wanting. These are the clavicles, as I suppose them to be. Each of these consists of a horizontal portion and an ascending portion. The former is nearly a quarter of a circle in form, with its convex outline presenting inwards and backwards. The border is marked by radiating ridges which terminate in a suture-like rugosity of the edge. The lower surface curves rapidly into the ascending portion, which is narrow and acuminate and about twice as high as the horizontal portion extends inwards from its interior border at the base. It displays on its external border an extensive sutural surface for union with the scapula. The anterior extremity of the epicoracoid lies on the superior (internal) face of the horizontal portion of the clavicle, extending nearly to its anterior border. Its external margin thins out in contact with the clavicle.

The above structure is peculiar among *Reptilia* in the widely-expanded subtriangular distal part of the clavicle. It presents no greater resemblance to any known mammal. Its character is more that of the Stegocephalous *Batrachia*, and it is a good deal like the lateral thoracic shield of the animals of that group, as, for instance, *Actinodon* of Gaudry and *Cricotus* m. From the sutural character of the borders of this part I anticipate the discovery of a median or mesosternal element. It is possible that the piece attached to its superior face, which I have above alluded to as epicoracoid, may be a part of this bone displaced laterally.

The resemblance of the humerus of this and of allied genera to that of the mole was reported by the writer in the American Naturalist, 1878, p. 408 (June), and the nearer resemblance to *Echidna* was asserted in the same journal, 1878, p. 830 (December).

Art. III.—On a Wading Bird from the Amyzon Shales.

By E. D. Cope.

The formation which I have called the Amyzon Shales is a lacustrine deposit of Tertiary age which is found in the South Park of Colorado, in Northeastern Nevada, and probably in Central Oregon.* Its material is laminated, and is occasionally highly carbonaceous. It contains many specimens of fossil fishes, of plants, and of insects, and allied articulates. Its age is uncertain, but it is probably near the Upper Eocene or Lower Miocene. Remains of birds are very rare, the best-preserved specimen yet found being that of a Passerine species. Under the impression that it belongs to the *Fringillidæ*, Mr. J. A. Allen describes it under the name of *Palæospiza bella*.†

The present communication relates to a second species of bird from the same formation. The specimen includes three vertebræ anterior to the pelvis; the pelvis, with the vertebræ which it incloses, and the caudal vertebræ; both femora; the tibia and part of the tarsometatarse of the right leg, with the greater part of the left tibia. One-half of the tail is preserved, the feathers lying in almost undisturbed relation. There are also various light and downy feathers of the base of the tail and adjacent parts of the body lying on the block, some in place, others loose.

The characters displayed by the bones and feathers are those of a species of the order *Grallæ* and tribe *Limicolæ* (*Totanideés* A. Milne Edwards). In the absence of important parts of the skeleton, it is not possible to ascertain the family characteristics, but it is more easy to assign the species to its genus. I cannot detect any features which forbid its reference to the genus *Charadrius* in the large sense. It presents important resemblances to the species of *Totanus*, but there are some reasons, to be mentioned later, why this reference is inadmissible. It is clear that there are various genera of *Scolopacidæ* to which it cannot be referred, on account of the form of its *ossa ischii*. I therefore introduce it to the scientific record under the name

CHARADRIUS SHEPPARDIANUS.

Chars.—Femur one-half the length of the tibia; nine caudal vertebræ; tail gently wedge shaped, apparently without color cross-bars.

* American Naturalist, May, 1879.

† Bulletin U. S. Geol. Survey Territories, Vol. IV, 1878, p. 443, Pl. I.

Description.—The preiliac vertebræ are distinct from each other and have only moderately elongate centra. The diapophyses are of moderate length and less width, and are truncate at the extremity. Those of successive vertebræ are connected by but few osseous ligamentous spicules. The caudal vertebræ are short and wide, and have short diapophyses, except the first, which has a long narrow diapophysis. The last three are in profile, and do not display hypapophyses. The ploughshare bone is an elongate triangle, considerably produced to its superior angle. The basal cotylus for articulation with the centrum immediately infront, is well excavated.

The pelvis is short and rather wide posteriorly. The fossil presents a superior view of it, with both the pubic bones turning their external faces upwards. The external borders of the anterior plates of the ilia are broken away, but enough remains of their inner portion to show their anterior extent. The postacetabular ridges diverge outwards and terminate in a prominent angulation of the posterior border which is about equidistant between the vertebral border of the ilium and the externo-inferior border of the pubis. The posterior outline thus differs from that seen in various genera of *Scolopacidæ*, where the angle is much nearer the vertebral border, and where a second angle is produced by a notch at the point of junction of the ischium. The pelvis of *Totanus* is however, much like that of the present species. External to the angular projection described, the border is notched, and then turns posteriorly, forming a gentle curve, which continues from the ischium to the slender pubis. The pubis is long and very narrow, and extends well posterior to the ischium. It is of uniform diameter, and is not expanded distally. The ischiopubic foramen is long and narrow, about one-seventh as wide as long. The obturator foramen is about one-third the length of the ischiopubic, and is oval. A transverse line cutting the anterior border of the acetabulum divides the pelvis between the posterior angular projection of the ilium (the true crest, *fide*, Gegenbaur) and the anterior extremity, into two parts of equal length.

The leg bones are quite slender, and are similar in proportions to those of several species of *Charadrius* and *Totanus*. They are more slender than in various species of *Scolopax*, *Strepsilas*, *Tringa*, &c., and less so than in *Himantopus* and *Recurvirostra*. The former is just half as long as the tibia, and seen in profile is almost straight. The crest of the tibia is very prominent, but is not produced proximally. The distal extremity of the tibia and proximal part of the tarsometatarse are so damaged as not to furnish satisfactory characters.

There are five rectrices visible in the specimen. Those which are in all probability median are the longest, while the external two are of equal length. This gives the outline a rather short wedge shape as the feathers lie closed. The expanded tail would be rounded with a slight median angulation. The extremities of the feathers are rounded, and

their whole structure is soft and delicate. The length of the longest rectrix is just about that of the tibia.

Measurements.

	M.
Length of the preiliac vertebræ	.010
Length of centrum of first vertebræ	.0035
Length of sacrum	.021
Length of caudal vertebræ on curve	.0145
Length of plowshare bone to apex	.005
Length of ilium	.024
Length of ilium to acetabulum	.012
Length of ischium from acetabulum	.016
Length of pubis from acetabulum	.019
Width between posterior angles of ilia	.009
Length of femur	.024
Diameter of femur at middle	.003
Length of tibia	.047
Antero-posterior diameter at head	.006
Diameter of shaft at middle	.0027
Diameter of head of tarsometatarse	.004
Length of median rectrix from plowshare bone	.046
Length of external rectrix from plowshare bone	.040
Width of portion of tail preserved	.020

The strongly contrasted light and dark shades of color are not unfrequently preserved in the insects of this formation. I suspect that had the rectrices of this species originally displayed the alternating white and dark cross-bars characteristic of the *Totani*, some trace of them would be discoverable in the fossil, in spite of the fact that the entire feather is represented by carbon only. The brown tint of the specimen, both light and dark, is uninterrupted by pattern of any kind.

The tail is rather longer than in the *Tringæ*, about equal to that of many plovers and *Totani*, and shorter than that of *Actiturus*.

The *Charadius sheppardianus* was discovered near Florissant, Colorado, by Dr. G. Hambach, a skillful naturalist. I have named it in honor of Edwin Sheppard, of Philadelphia, an excellent ornithologist and skillful artist.

Art. VII.—On the Nimravidæ and Canidæ of the Miocene Period.

By E. D. Cope.

In following the general series of the *Carnivora*, we pass, as in other orders, from the generalized to the specialized types. That we should begin with the *Procyonidæ* and their allies is indicated by all the characters to be especially considered in the case. They have five toes on all the feet, and are plantigrade, resembling in these points all primitive *Mammalia*.* They have the original number of molar teeth, seven on each side, and of these none are distinctly developed sectorials. The condyloid and carotid foramina are distinct, and there is a postglenoid foramen. If, starting from this point of departure, we arrange the succeeding families of *Carnivora* according to their resemblances and differences in these respects, we have a tolerably consecutive series of divisions.

Passing at present over the families *Mustelidæ*, *Viverridæ*, *Cryptoproctidæ*, and others with five toes on all the feet, we reach those in which the hind foot has lost a digit, leaving the number 5–4. These are the *Protelidæ*, *Canidæ*, and *Felidæ*. We can take but one step further in this order; that is to those species where the anterior foot has also lost a toe, which constitute the family *Hyænidæ*. The toes are therefore, here, 4–4. For the well-marked characters of the three families mentioned just before, I refer to another page, and proceed to define briefly the division which has been heretofore termed the *Felidæ*. In doing so I am compelled to omit several of the characters generally employed to define that family, since I have found them to be wanting from various extinct genera. The only comprehensive definition which I can give is the following:

Digits 5–4; sectorial teeth well developed in both jaws; not more than one true molar tooth in the upper nor more than two true molar teeth in the lower jaw. Glenoid cavity grasping mandibular condyle anteriorly as well as posteriorly.

Professor Gill, who has devoted much attention to the definition of the families of the *Mammalia*,† gives the following skeletal characters

* See Homologies and Origin of Types of Molar Teeth of Mammalia Educabilia, Journal Academy Phila. 1874, March.

† Arrangement of the Families of Mammals,-Smithson. Miscell. Coll. 230, 1872, p. 56.

in his diagnosis of the *Felidæ*, and of the three comprehensive divisions within which he places it: "I. Skull with the paroccipital process applied closely to the auditory bulla; the mastoid process small or obsolete; external auditory meatus very short or imperfect. Div. A. Carotid canal minute and superficial or obsolete; condyloid foramen and foramen lacerum posticum debouching into a common fossa; glenoid foramen minute or null. Os penis rudimentary. Subdiv. 1. Otic bulla divided by a septum into posterior and anterior chambers, communicating by a narrow aperture (Flower). Subdiv. *a*. Skull with no alisphenoid canal." All of the parts above mentioned I have found to be important in the definition of the natural divisions of the *Carnivora*, excepting those derived from the paroccipital and mastoid processes. But their condition in the extinct *Carnivora* which have been hitherto arranged with the *Felidæ*, and which resemble them very much in superficial characters, does not coincide with Professor Gill's definition. Thus, in the various American genera which are allied to *Drepanodon*, the carotid canal is distinct from the *foramen lacerum posterius*, and the condyloid foramen is also separated from it by quite a space. These are characters which belong to most of the *Carnivora* with five digits on all the feet. Further, the postglenoid and postparietal foramina are present; also characters of the lowest *Carnivora*, as the bears and certain extinct dogs. Then, there is an alisphenoid canal, which is also found in bears, dogs, and the cat-like *Cryptoprocta*. I cannot demonstrate that the otic bulla is divided, as the above diagnosis requires, in any of the fossil species. I have verified these characters on species of the following genera, of which I have well-preserved skulls: *Archælurus*, *Nimravus*, *Dinictis*, *Pogonodon* (except those of the basal axis of the skull), and *Hoplophoneus*. Three genera as yet only found in Europe are similar in general characters, and probably agree with them. I allude to *Proælurus* Filh., *Ælurogale* Filh., and *Eusmilus* Gerv. On the other hand, the genus *Smilodon*, which includes the American saber-tooths of Pliocene age, agrees with the true cats in the points in question; *i. e.*, the alisphenoid, postglenoid, and postparietal foramina are wanting, the carotid foramen is either internal or wanting, and the condylar enters the jugular foramen at its mouth. This surprising condition of affairs makes it important to learn the characters to be found in the species of the longest-known genus, *Drepanodon*, of the European beds. But although there are several good crania in European museums, I can find no description of their minute characters, and no mention made of their foramina. The probabilities are, on various grounds, that this genus agrees with *Smilodon* in the latter characters. The reasons in favor of this supposition are the agreement in special dental characters, and the Pliocene age of the typical species, *D. cultridens*. Whether the middle Miocene species of Sansan and Epplesheim agree with this one in structure, is of course uncertain.

Seven, and perhaps eight, genera, then, constitute a group to be dis-

tinguished from the true *Felidæ*, and, as it appears to me, as a distinct family. Should we ignore the characters adduced in this instance, we abandon at the same time the definitions of several of the other families of the order, and in fact throw the system into confusion. I have proposed to call this family the *Nimravidæ*, and have contrasted it with the *Felidæ* in the following definition. Both are included in the division already defined on a preceding page.

No distinct carotid foramen nor alisphenoid canal; condylar foramen entering the foramen lacerum posterius. No postparietal and generally no postglenoid foramina ..... *Felidæ*.

Carotid and condylar foramina entirely distinct from the foramen lacerum posturius; an alisphenoid canal, and postglenoid and postparietal foramina ..... *Nimravidæ*.

NIMRAVIDÆ.

The dental characters of the *Nimravidæ* are in general, those of the *Felidæ*, the higher genera having the same dental formula. Descending the scale, the number of molar teeth increases at both ends of the series in the lower jaw, and anteriorly only in the upper, but the number of the true molars never exceeds $\frac{1}{2}$. The following table gives the definitions of the genera. I am unfortunately ignorant of the characters of the foramina in *Procælurus* and *Pseudælurus*, as well as in *Ælurogale* and *Eusmilus*.

I. Lateral and anterior faces of mandible continuous; no inferior flange.
  a. Inferior sectorial with a heel; canines smooth.
    Molars $\frac{4}{4}$ $\frac{1}{1}$; inferior sectorial with interior tubercle ..... *Procælurus.*
    Molars $\frac{3}{3}$ $\frac{1}{1}$; inferior sectorial without interior tubercle ..... *Pseudælurus.*

II. Lateral and anterior faces of mandible separated by a vertical angle; no inferior flange; incisors obspatulate.
  a. No anterior basal lobe of superior sectorial; inferior sectorial with a heel (and no internal tubercle); incisors truncate.
    Molars $\frac{4}{4}$ $\frac{1}{1}$; canine smooth ..... *Archælurus.*
    Molars $\frac{3}{4}$ $\frac{1}{1}$; canine denticulate ..... *Ælurogale.*
    Molars $\frac{3}{3}$ $\frac{1}{1}$; canine denticulate ..... *Nimravus.*

III. Lateral and anterior faces of mandible separated by a vertical angle; an inferior flange; incisors conic; canines denticulate.*
  a. No anterior basal lobe of superior sectorial; † inferior sectorial with a heel; no posterior lobes of the crowns of the premolars.
    Molars $\frac{3}{3}$ $\frac{1}{1}$ ..... *Dinictis.*
    Molars $\frac{3}{3}$ $\frac{1}{1}$ ..... *Pogonodon.*
    Molars $\frac{2-3}{2}$ $\frac{1}{1}$ ..... *Hoplophoneus.*
    Molars $\frac{?}{1}$ $\frac{?}{1}$ ..... *Eusmilus.*

It is readily perceived that the genera above enumerated form an unusually simple series, representing stages in the following modifications of parts: (1) In the reduced number of molar teeth; (2) in the

* Gervais's figures of the canines of *Eusmilus bidentatus* represent no denticulations, but the figure is not clear.

† Rudimental in *Hoplophoneus.*

enlarged size of the superior canine teeth; (3) in the diminished size of the inferior canine teeth; (4) in the conic form of the crowns of the incisors; (5) in the addition of a cutting lobe to the anterior base of the superior sectorial tooth; (6) in the obliteration of the inner tubercle of the lower sectorial, and (7) in the extinction of the heel of the same; (8) in the development of an inferior flange and latero-anterior angle of the front of the ramus of the lower jaw; (9) in the development of cutting lobes on the posterior borders of the larger premolar teeth.

(1) The reduction in the number of molar teeth. The dental formula of *Procælurus* is that of some *Viverridæ* and *Canidæ*, and the reduction from this point to the end of the series is obvious. In *Eusmilus*, as in *Smilodon*, the number of molars is less by one in the inferior series than in *Lynx* and *Neofelis*, where the formula is the smallest known among *Felidæ* proper, viz: $\frac{2}{2}\ \frac{1}{1}$. (2) The enlarged size of the superior canine teeth. In *Procælurus* and *Pseudælurus* the canines of both jaws are developed, as in recent *Felidæ*. In *Archælurus* the superior is the larger, but does not, relatively to the molars, exceed that of *Felis*. It is rather compressed in form and has a sharp cutting edge posteriorly. In *Nimravus* the superior canine begins to have the enlarged size of the saber-tooths, but its form is peculiar in the *N. gomphodus*, being spike-shaped rather than saber-shaped. We find the true saber shape first in *Dinictis*, where it is compressed, and with a denticulate cutting edge on both front and rear. In *Pogonodon* it has reached a very large size, and it does not display much increase in this respect until we reach the last genus of the series, *Eusmilus*, where its proportions are enormous, almost as large as in the feline genus *Smilodon*, where they appear to have been an inconvenience to the animal. (3) The diminished size of the inferior canines becomes evident in the lower genera of the third division (supra) of the *Nimravidæ*, but is most decided in the highest genera, *Hoplophoneus* and *Eusmilus*. (4) The incisor teeth have the usual obspatulate or obovate outline in the genera of the first and second divisions of the family, including *Nimravus*. They are conic in the true saber-tooths with flared lower jaw, beginning with *Dinictis* and ending with *Eusmilus*. (5, 6, and 7) The structure of the sectorials. The presence of a heel and an inner tubercle of the lower sectorial are well-known characters of a majority of the *Carnivora*. In only the most highly organized genera are they wanting, and among them are included all those of the *Felidæ* that still exist. In the *Nimravidæ* the inferior genera have both in a reduced degree, and they soon disappear as we ascend the scale. Thus, the inner tubercle is only present in the species of *Procælurus*, *Dinictis*, and *Hoplophoneus*. The heel, on the other hand, remains throughout the entire family. The anterior basal lobe of the superior sectorial has the same history, its absence being characteristic of the inferior *Carnivora*, and of all the genera of *Nimravidæ* except *Hoplophoneus*, where it is rudimental. It is well developed in *Drepanodon* as in recent *Felidæ*, and is sometimes double in *Smilodon*. (8) The

levelopment of the inferior flange and latero-anterior angle of the manlibular ramus. There is a successive advance in the development of hese characters, beginning with the second group, for in the first they re wanting. The latero-anterior angle is developed in *Archælurus* and llied genera, and is merely continued on the inferior border of the amus. In the third group it is much more acute, and is deflected downwards, forming the well-known flange of the saber-tooths. It is longest n the *Eusmilus bidentatus* Filh. (9) The highest genera of *Nimravidæ*, . g. *Hoplophoneus*, differ from the true *Felidæ* in the absence of the cutting lobes on the posterior edges of the crowns of the larger premolar eeth. But, according to Filhol, these lobes are present in the generalized genera *Proælurus* and *Pseudælurus*, which are thus brought into a relation with the *Felidæ* not possessed by other *Nimravidæ*.

A characteristic perfection of the *Felidæ* is seen in the genus *Smilodon;* that is, the vertical direction of the ungual phalanges, by which the claws become retractile. This is well displayed by the two splendid specimens of *Smilodon necator* from Buenos Ayres, which have been preserved.* Unfortunately, these phalanges have not yet been described in any species of the *Nimravidæ*, and it is not yet certain what their structure really was. Among the true *Felidæ* the genus *Cynælurus* displays a less degree of development in this respect than the other genera, the ungual phalanges lacking the proximal process below the articular facet. Such a condition is to be looked for among the less perfect genera of *Nimravidæ*.

The succesion of genera above pointed out coincides with the order of geologic time very nearly. Those belonging to groups first and second belong to the Lower and Middle Miocene, except *Ælurogale*, which is perhaps Upper Eocene, and *Pseudælurus*, which is Middle Miocene. The genera of the first group of division third have the same Lower Miocene age, except *Eusmilus*, which has been found in the same formation (Phosphorites) as the *Ælurogale*. *Drepanodon* is Upper Miocene, and *Smilodon* is Pliocene.

The relations of these genera are very close, as they differ in many cases by the addition or subtraction of a single tooth from each dental series. These characters are not even always constant in the same species, so that the evidence of descent, so far as the genera are concerned, is conclusive. No fuller genealogical series exists than that which I have discovered among the extinct cats.

As to the phylogeny of this family, there are flesh-eaters of the Eocene period which may well have been the ancestors of both the *Nimravidæ* and *Felidæ*.† I have suggested that this position is most appropriately held by the *Oxyænidæ*, a family of several genera, which included the most formidable, rapacious mammals of that early period in both continents.

* See American Naturalist, December, 1880, fig. 12.

† See On the Genera of the *Creodonta*, by E. D. Cope, Proceed. Amer. Philos. Soc. July, 1880.

The interval between them and the *Nimravidæ* is, however, great, for in the *Oxyænidæ*, when there is a superior sectorial tooth, the first true molar in the upper jaw is utilized instead of the last premolar, and the second true molar below is a sectorial as well as the first. Several intervening forms must yet be found to complete the connection, if it have ever existed. It is, however, very likely that the true *Felidæ* were derived from the genus *Proælurus*, through *Pseudælurus*, if indeed these two genera be not the primitive members of that family, for, as above remarked, the evidence of their possession of the characters of the *Nimravidæ* has not yet been obtained. There can be no reasonable doubt that the genera *Drepanodon* and *Smilodon* in the *Felidæ* are the descendants of *Hoplophoneus* and allied genera. In fact, the *Nimravidæ* and *Felidæ* are "homologous groups", having corresponding terms in the manner I foreshadowed as a general principle in 1868 (Origin of Genera).

In looking for causes in explanation of the modifications of structure cited, one can easily discover that there is a close relation between the arrangement of the teeth and the mechanical laws involved in the performance of their function, that of seizing an active prey and of cutting up their carcasses into pieces suitable for swallowing. It is obvious that in the latter case the flesh-teeth bear the resistance and the masseter muscle is the power, and that the nearer these parts are together the better is the function performed. As a matter of fact, the sectorial teeth in modern *Carnivora* are placed exactly at the angle of the mouth, which is nearly the front border of the masseter muscle.

Both the muscle and the teeth have, however, moved forwards in connection with the shortening of the jaw behind. This has been due to the necessity of bringing the power (masseter) nearer to another point of resistance, viz, the canine teeth. In the early carnivores (as *Hyænodontidæ*) the long jaws supported more numerous teeth ($\frac{4-3}{4-3}$) than in any modern families, and the fissure of the mouth was probably very wide. The canine teeth were evidently very ineffective weapons. The animals probably only snapped with their jaws, and did not attempt to lacerate or hold on, as do the cats. The dogs of to-day are long-jawed, and they snap in a manner quite distinct from anything seen among the cats. The only dogs that hold on are the short-jawed bulldogs.

So in the use of the canines, we have the ground of the shortening of the jaw behind and before, and the consequent change of structure, which resulted in the modern perfected *Felidæ*.

The following list shows the number and distribution of the species of the *Nimravidæ*. The position of a cross on a line indicates an intermediate geological position.

	Upper Eocene.	Lower Miocene.		Upper Miocene.		Pliocene.	
	Europe.	Europe.	America.	Europe.	America.	Asia, Europe.	America.
Proælurus julieni Filh		+					
Proælurus lemanensis Filh		+					
Pseudælurus hyænoides Blv				+			
Pseudælurus edwardsi Filh	+						
Pseudælurus intrepidus Leidy					+		
Pseudælurus sivalensis Lydd						+	
Archælurus debilis Cope			+				
Ælurogale intermedia Filh	+						
Ælurogale acutata Filh							
Nimravus gomphodus Cope			+				
Nimravus confertus Cope			+				
Dinictis felina Leidy			+				
Dinictis cyclops Cope			+				
Dinictis squalidens Cope			+				
Pogonodon platycopis Cope			+				
Pogonodon brachyops Cope			+				
Hoplophoneus oreodontis Cope			+				
Hoplophoneus primævus Leidy			+				
Hoplophoneus occidentalis Leidy			+				
Hoplophoneus cerebralis Cope			+				
Eusmilus bidentatus Filh	+						

DESCRIPTIONS OF NEW SPECIES.

NIMRAVUS GOMPHODUS sp. nov.

Nimravus brachyops Cope, Proceed. Academy Philad. 1879, p. 170, not *Machærodus brachyops* Cope, Proc. Am. Phil. Soc. 1878, p. 72.

This carnivore is represented by parts of three individuals; one of them by a nearly complete skull. The species is rather larger than the average *Uncia concolor*.

Measurements of skull.

	M.
Axial length from occipital condyles to premaxillary border	.206
Axial length from inion to premaxillary border	.220
Axial length from premaxillary border to canine tooth	.017
Axial length from premaxillary border to anterior border of superior sectorial	.066
Axial length from premaxillary border to posterior extremity of maxillary bone	.097
Axial length from premaxillary border to postglenoid process	.162
Length of nasal bone from nasal notch	.065
Length of sagittal crest from inion	.082
Width of premaxillary bone (greatest)	.019
Width of each nasal bone at middle	.008
Width of each frontal bone at middle of orbit	.028
Width of each frontal bone at postfrontal angles	.035
Width of skull at anterior part of zygoma	.098
Width of zygomata at temporal fossa	.111
Width of skull at meatus auditorius	.074
Width of skull between apices of paroccipital processes	.054
Width of occiput at middle	.044
Width of foramen magnum	.024

	M.
Elevation of occiput above foramen	.036
Width of chin at base	.022
Width of chin at summit	.028
Depth of chin	.040
Depth of ramus at diastema	.027
Depth of ramus below last premolar	.031
Length of ramus	.157
Elevation of condyle	.033
Elevation of coronoid process	.071
Length of superior canine	.045
Diameters of base of superior canine { antero-posterior	.016
Diameters of base of superior canine { transverse	.008
Anteroposterior diameter at middle	.010
Distance from canine to third premolar	.016
Length of molars, including third premolar	.045
Length of base of third premolar	.018
Elevation of cusp of third premolar	.013
Length of base of sectorial	.025
Elevation of cusp of sectorial	.015
Width of tubercular	.009
Elevation of inferior canine	.024
Antero-posterior diameter of inferior canine at base	.012
Length of inferior diastema	.022
Length of inferior molar series	.063
Length of third premolar	.017
Elevation of third premolar	.017
Length of fourth premolar	.020
Elevation of fourth premolar	.015
Length of sectorial	.025
Elevation of median cusp of sectorial	.016

The characters of this species will be fully detailed in my final report to Dr. Hayden, now passing through the press.

From the John Day River, Oregon.

NIMRAVUS CONFERTUS sp. nov.

This species is as yet represented by a mandibular ramus only. It is one-third smaller than that of *N. gomphodus*.

The inferior border of the ramus is broken off, excepting for a space below the diastema. The general form is narrow, as in *N. gomphodus*, and there is a projecting ledge along the inner base of the sectorial similar to that seen in the latter species. The angle separating the side from the front of the ramus is rather stronger than in *N. gomphodus*, but there is no indication of an inferior flare. The diastema is shorter than in the typical species, its length equalling that of the base of the third (first) premolar; in *N. gomphodus* it is half as long again. The symphysis is correspondingly shorter, ceasing a little in advance of, and at the posterior border of, the inferior canine tooth, while in *N. gomphodus* it continues for one diameter of the canine behind its posterior border.

The crown of the inferior canine tooth is directed backwards, and its

errate cutting edge is presented almost entirely inwards. The interno-nterior face of the crown is flat, and has a low shoulder at the base. The nolars have the proportions of those of *N. gomphodus*, differing only in heir smaller size, which is very apparent, as can be seen by the measure-nents. The first (third) premolar is a little longer on the base than high, nas no anterior tubercle, and has a short cutting basal heel. The fourth premolar has subequal anterior and posterior basal cutting lobes, and the base is longer than the elevation of the median cusp. The sectorial tooth nas a short cutting heel, but no trace of inner tubercle. The anterior lobe s as long as the median, but not so high. It overlaps the fourth premo-ar as far as the base of the median cusp. No incisor teeth are pre-erved in the specimen. Tubercular small.

Measurements of skull.

	M.
Depth of ramus at diastema	.020
Depth of chin	.027
Elevation of inferior canine	.016
Diameter of inferior canine at base	.010
Length of inferior diastema	.014
Length of inferior molar series	.053
Length of third premolar	.014
Elevation of third premolar	.010
Length of fourth premolar	.016
Elevation of fourth premolar	.013
Length of sectorial	.022
Elevation of median cusp of sectorial	.015

One specimen, from the John Day Valley, Oregon, found in the Truckee ormation, by J. R. Wortman.

COLOREODON RYDERANUS sp. nov.

Represented by a nearly complete skull, without lower jaw. These ndicate the third and smallest species of the genus. The specimen be-onged to an adult animal, as indicated by the condition of the last two nolar teeth.

Besides the small size, two characters may be cited as distinguishing his species from those already known. First, the temporal ridges con-verge very gradually, so that the sagittal crest does not appear anterior to he line of the otic bullæ, posterior to which point the skull is broken above. Second, the face is constricted immediately posterior to the po-sition of the fundus of the alveolus of the canine teeth. The position of his alveolus is prominent, and occupies the superior half of the maxil-ary bone, which is excavated beneath it. This excavation is bounded behind by the infraorbital foramen. The lachrymal bone presents an ngle into the orbit. The latter is open posteriorly, but the opposing processes approach each other. The zygomata are slender. The enamel of the molars is slightly wrinkled.

Measurements of skull.

		M.
Total length from left side of inion to front of canine		.147
From same to end of maxillary bone		.075
From same to palatal notch		.087
Length of diastema		.011
Length of molar series		.059
Length of true molars		.035
Diameters of second true molar	antero-posterior	.013
	transverse	.015
Diameters of third true molar	antero-posterior	.015
	transverse	.019

The linear measurements of this skull are three-fourths that of *C. ferox*, and three-fifths that of *C. macrocephalus*.

Found by J. L. Wortman, on the John Day River, Oregon.

Dedicated to my friend John A. Ryder, of Philadelphia.

PALÆOCHŒRUS PLATYOPS sp. nov.

Established on a nearly complete skull, which lacks the muzzle anterior to the third premolar teeth, the lower jaw, and parts of the zygomata. The last superior molar is not protruded, and it is probable that the fourth deciduous premolar still remains in the jaw.

The size of this species exceeds that of any other member of the genus. The postorbital process is also more elongate, so as to inclose the orbit to a greater extent than is usual in *Palæochœrus*. The temporal ridges are strong, and rise into a convexity above the anterior part of the temporal fossa. From this point they converge gradually to form the sagittal crest, which has a truncate edge. Between the ridges the surface is concave, the basin widening forwards as far as a line passing through the posterior third of the orbits. The frontal bone rises steeply from the orbit to the edge of this basin, and is regularly convex in front of it. The profile descends forwards, so that the section at the infraorbital foramen is broadly convex, and not compressed, as in the species of *Palæochœrus* from the Truckee beds of Oregon. The emargination of the palate extends as far forwards as the line of the anterior border of the second true molar. The posterior border of the infraorbital foramen is above the middle of the anterior root of the fourth premolar. The postglenoid, mastoid, and postparietal foramina are present; the last named rather small and in the inferior part of the parietal bone.

The base of the fourth premolar is remarkably extended antero-posteriorly. Its crown has a posterior basal cingulum, and is in contact with those of the molars anterior and posterior to it. The crown of the first true molar is narrowed inwards, the anterior border being more oblique than the posterior. Both of these borders have a wide cingulum. There are two large external cusps, with antero-posterior continuous edges, two small median cusps, and a larger internal cusp. No internal or external cingula. The second true molar is also narrowed inwards, but less so than the first, and the posterior border is the only

blique one. There are wide posterior and anterior cingula, and five usps arranged as in the first molar. The internal cusp is relatively arger in this tooth.

Measurements of skull.

	M.
ength from occipital condyles to anterior border of last premolar	.186
ength from occipital condyles to palatal edge	.135
ength from occipital condyles to line of anterior border of glenoid fossa	.051
Vidth of occiput above	.046
Vidth at posterior origin of zygomata	.071
Vidth between orbits (least)	.077
Vidth at middles of first molar teeth	.098
Vidth between first molar teeth	.040
levation of occiput, with condyles	.082
levation of muzzle at front of fourth premolar	.043
Diameters first molar, antero-posterior	.021
Diameters first molar, transverse	.016
Diameters second molar, antero-posterior	.022
Diameters second molar, transverse	.019

This species is easily distinguished from those which have been dis-overed heretofore, by its large size, by the peculiar form of its molar eeth, and by its flattened muzzle. The specimen above described was liscovered by Capt. Emmett Crawford, Third Cavalry, U. S. A., on the ipper waters of the Big Cheyenne River, Dakota, in a bed of the White River formation. It was presented to me by Dr. William H. Corbusieur, J. S. A., to whom my especial thanks are due.

PROTOLABIS PREHENSILIS sp. nov.

This camel is supposed to have existed on the evidence of portions of he mandibles of two individuals. These include the symphyseal por-ion, and one of them the ramus as far posteriorly as the first true nolar, inclusive. These remains indicate a robust species of the size of he *Procamelus angustidens*, or between the *P. gracilis* and *P. robustus*.

The most marked peculiarities of this species are the following: The anine and first premolar are very robust, and the latter is one-rooted nd with an oval section at the base like the canine. The second pre-molar is also one-rooted, while the third and fourth are two-rooted, and liffer very little in size from each other. The first true molar is abruptly larger, although narrowed in front. The root of the second premolar is round and of robust proportions, its diameter being one-half linear that of the first. The roots of the incisors are robust, that of the first being rather larger than that of the third. The symphysis terminates a little behind the line of the first premolar. The mental foramen is unusually extended in the antero-posterior direction.

Measurements of skull.

	M.
Length of symphysis (No. 1)	.080
Length of bases of incisors and canine	.043
Diameters of canine, antero-posterior	.016
Diameters of canine, transverse	.011

	M.
Diameters of premolar (I) { antero-posterior	.01
Diameters of premolar (I) { transverse	.00
Length of last three premolars on base (No. 2)	.03
Length of base of fourth premolar	.01
Length of base of first true molar	.01
Length of first diastema (No. 2)	.01
Length of second diastema (No. 1)	.02
Depth at second diastema (No. 1)	.03
Depth at first true molar	.04

The generic position of this species is uncertain. I place it provisionally in *Protolabis* on account of the large development of the inferior incisors. Its robust canine and first premolar, and small third and fourth premolar distinguish it from any of the species described.

Found by R. H. Hazard, in the Loup Fork beds of Southern Nebraska.

EUMYS LOCKINGTONIANUS sp. nov.

This rodent is represented by a nearly perfect skull, which is without lower jaw. Its specific characters separate it widely from the *E. elegans* Leidy and *E. nematodon* Cope. It is considerably larger than either and the temporal ridges are very obsolete and do not unite posteriorly to the orbits, as in *E. elegans*, resembling in this respect the *E. nematodon*. The parietal region is wide and flat above. The interorbital region is only moderately contracted. The muzzle is rather short as compared with the total length of the skull. The interorbital region is gently convex above, and the top of the muzzle is flat. The zygoma is quite slender, and the otic bullæ are large and prominent. The notch of the palate extends as far forwards as the posterior part of the last superior molar. The infraorbital foramen is very large and round.

The anterior face of the superior incisor is nearly plane, and it is marked by a weak groove near the inner and a strong groove near the external border. In *E. elegans* this face is convex and without grooves. The molars are rather small for the size of the skull; their crowns are worn by use. The third is subround in section, and its diameter is about half that of the first; the latter has the anterior odd lobe quite small.

Measurements.

	M.
Total length of skull	.038
Length (axial) to front of orbits	.014
Length (axial) to palatal notch	.019
Length (axial) to first molar	.012
Width at otic bullæ	.020
Width at middle of zygomata	.022
Width of interorbital space	.006
Width between first molars	.005
Length of molar series	.007
Length of first molar	.003
Width of superior incisor	.001

This species is dedicated to my friend W. N. Lockington, the well-known naturalist of San Francisco.

CIURUS BALLOVIANUS sp. nov.

This squirrel is the second species of its genus supposed to occur in ıe Truckee beds of Oregon, and the third *Sciurus* obtained thus far from ıe Lower Miocene or Oligocene of the West. The typical specimen for-ınately includes the cranium, with both rami of the mandible, so that s reference to the genus *Sciurus* rather than to *Gymnoptychus* is assured. ike the latter genus, the infraorbital foramen is reduced to a slit, but, ılike it, there is but one internal tubercle of the crowns of the superior ıolars instead of two.

The skull is flat above, and the interorbital space is also flat, and is :markably wide. Temporal ridges none. Muzzle short and narrow. alate wide, its posterior notch extending as far forwards as the last ıperior molar. The ascending ramus of the mandible originates oppo-te the anterior part of the last inferior molar. The massateric fossa xtends to opposite the anterior border of the second inferior molar. The ıental foramen is near the superior border of the posterior part of the iastema. The second and third superior molars, the only ones pre-:rved, have two cross-crests and a strong anterior cingulum. The xternal extremities of the cross-crests are little elevated, and there are o other cingula. The inferior molars have basin-shaped grinding faces, ith a lobe at each angle. There is a small tubercle between the lobes f the inner and outer pairs. The incisors of both jaws are much com-ressed, strongly convex in front, and, in the lower jaw at least, without :ulpture.

Measurements.

	M.
ength of skull to orbit	.0090
idth between orbits	.0090
idth of muzzle	.0047
idth between last molars	.0040
ength of superior dental series	.0054
iameters of second molar { antero-posterior	.0015
iameters of second molar { transverse	.0016
idth of superior incisor	.0013
ength of mandibular ramus	.0150
levation of ramus at coronoid	.0080
ength of diastema	.0030
ength of inferior dental series	.0070
epth of ramus at second molar	.0045

This species is much smaller than the *Sciurus vortmani*, from the same orizon of Oregon. The type specimen was discovered by Mr. L. S. avis, of Mr. Wortman's party. The name is given in honor of Mr. [. H. Ballou, of Chicago, a naturalist and journalist.

CANIDÆ.

Species of this family were very abundant during the Miocene period ı North America as in Europe. Those of the Lower and Middle liocene epochs belong to genera allied to, but distinct from, *Canis;* hile those of the Upper Miocene (Loup Fork) and later horizons, per-

tain to the latter genus, with few exceptions. The characters of th genera are as follows:

I. Molar formula $\frac{4}{4}$ $\frac{3}{3}$.
  Humerus with epitrochlear foramen ..... *Amphicyon*
II. Molar formula $\frac{4}{4}$ $\frac{3}{3}$.
  Humerus with epitrochlear foramen.
    Inferior sectorial heel trenchant ..... *Temnocyon*
    Inferior sectorial heel basin-shaped ..... *Galecynus*
  Humerus without epitrochlear foramen.
    Inferior sectorial heel basin-shaped ..... *Canis*
III. Molar formula $\frac{3}{3}$ $\frac{2}{2}$.
  Heel of inferior sectorial trenchant ..... *Enhydrocyon*
IV. Molar formula $\frac{4}{4}$ $\frac{1}{2}$.
  Heel of inferior molar basin-shaped ..... *Icticyon*
V. Molar formula $\frac{4}{3}$ $\frac{1}{1}$.
  First inferior molar two-rooted ..... *Hyænocyon*

To these genera I refer nineteen species of the American Miocenes.

AMPHICYON Lartet.

Bulletin Société Géologique de la France, 1836, vii, 217–220; Blainville Comptes-Rendus, 1837, v, 434; L'Institut, 1837, v, 18–19; Blainville, Oste graphie, ix, Subursus, 78–96.

Dental formula: I. $\frac{3}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{4}$; M. $\frac{3}{3}$. The true molars of the su perior series all tubercular; the last two of the inferior series also tube cular. First inferior true molar a sectorial, with an internal tubercl and a heel with a superior groove, bounded by raised borders. Hu merus with an epitrochlear arterial foramen.

Much is yet to be desired in the elucidation of the characters of th genus, especially of the American forms, which are less abundant an of smaller size than those of Europe. The typical species, *Amphicyo major* Blv. was the largest, equalling a bear in size. It is derived fro the Miocene of Sansan, and a smaller form of it is found, accordin to Pomel, at San Gerand-le-Puy. Other species are derived from th latter locality, and all are typical of the Miocene formation in Europ In the "Mio-pliocene" of India a single species has been discovered, th *A. palæindicus* of Lydekker. Three species occur in the Lower and Mi dle Miocene of North America, the largest of which about equals th wolf in size. On account of the large development of the inferior tube cular teeth, I have suspected that the *Canis ursinus* Cope, from th Loup Fork group of New Mexico, would prove to be an *Amphicyon*. so, it is the only representative of this genus in our Upper Miocene.

The three American species differ as follows: The *A. cuspigerus* small, not exceeding the kit-fox in dimensions. The *A. hartshornian* is about the size of the coyote, and has rather small tubercular molar especially of the lower series. The *A. vetus* is a little larger, but h the tubercular molars disproportionately larger than those of the *A. hartshornianus*.

TEMNOCYON Cope.

Paleontological Bulletin, No. 30, p. 6, December 3, 1878; Proceedings American Philosophical Society, 1878, p. 68.

Dental formula: I. $\frac{3}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{4}$; M. $\frac{2}{3}$. Two molars in each jaw tubercular. Inferior sectorial with well-developed heel, which is keeled with a cutting edge above. An internal tubercle of the same. A postglenoid, but no postparietal foramen. Humerus with an epitrochlear arterial foramen.

The characters on which I rely at present for the discrimination of this genus from *Canis* are two. The first is the presence of a cutting edge on the superior face of the heel of the inferior sectorial, in place of a double row of tubercles surrounding a basin. When well developed, these characters present a broad contrast, but indications of transitional forms are not wanting. Thus, in some extinct *Canes* the internal crest of the heel is less elevated than the external, which is the homologue of the single crest of *Temnocyon*, and in some specimens of *Temnocyon coryphæus* there is a cingulum on the inner side of the median keel, which represents the internal crest of *Canis*. Secondly, the epitrochlear foramen of the humerus, a character common to all of our Lower Miocene *Canidæ* yet known.

The keel of the sectorial, which defines this genus, is simply a repetition on that tooth of the heel which belongs to the posterior premolar teeth of many *Carnivora*. It finds resemblances in such Eocene forms as *Mesonyx* and *Palæonyctis*. Among recent *Canidæ* it is apparently unknown, and is very rare in other groups. The *Cynodictis crassirostris* Filhol, from the French Phosphorites, strongly resembles the species of *Temnocyon* in generic characters.

Three species of the genus are known to me. They may be distinguished as follows. A fourth species, *T. josephi*, is provisionally placed with these:

I. First superior tubercular molar with a wide median fossa, bounded within by a tubercle.

Length of superior molar series from canine, .070; of true molars, .0215. *T. altigenis.*

Length of molar series from canine, .067; of true molars, .014. *T. wallovianus* sp. nov.

II. First superior tubercular molar with narrower basin, bounded within by a V-shaped crest.

Length of dental series from canine, .055; of true molars, .014 ..... *T. coryphæus.*

Length of dental series from canine, .051; of true molars, .013; muzzle narrow, zygomas wide ..... *T. josephi* sp. nov.

All of the above species have been derived from the Truckee Miocene beds of Oregon. I, however, anticipate the discovery of these or other species of the genus in the White River beds of Dakota and Colorado.

GALECYNUS Owen.

Quarterly Journal Geological Society London, 1847, iii, 54–60.—"*Cynodon* Aymard, Annales Société du Puy, 1848, xii, p. 244.—*Cynodictis* Bravard et Pomel, Notice sur les Ossemens Fossiles de la Debruge, 1850, p. 5.—*Cyotherium* Aymard, Ann. Soc. d'Agric. du Puy, 1850, xiv, p. 115"; Bronn.

Dental formula: I. $\frac{3}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{4}$; M. $\frac{2}{3}$. Inferior sectorial with internal tubercle, and with a heel with raised or tubercular internal and external borders. First premolar in both jaws one-rooted. A postglenoid but no postparietal foramen. Humerus with an epitrochlear arterial foramen.

This genus, which is abundantly represented by species and individuals, existed during the Upper Eocene epoch in Europe (in the Phosphorites), and also during the White River or Oligocene in North America. As the structure of the feet of the numerous species from these epochs is not yet known, and, therefore, some doubt as to their correct generic reference may still exist, I only regard the genus as a certain inhabitant of North America during the Truckee or Middle Miocene epoch. This is indicated by the *Galecynus geismarianus*, where the number of the toes on the posterior foot has been ascertained.

All the species of the genus from Eocene and Lower Miocene beds, as well as most of those of the Loup Fork epoch, are characterized by the relatively small size of their sectorial teeth. In this they resemble the *Amphicyons*, *Temnocyons*, and other forms of *Canidæ* of the same period, and differ from such true *Canes* as *C. ursinus*, *C. sævus*, and *C. haydeni*, which display the enlarged sectorial teeth of the existing species of the genus. Of course there is every gradation in this respect between the two types. In the older species the internal tubercle of the inferior sectorial tooth is more largely developed than in the later ones, thus approaching some of the species of *Viverridæ*, where it is still more largely developed. As in other characters, there are gradations in this also, so that neither in it nor in the relative size of the sectorials do I find ground for the separation of the species in question from the genus *Canis*, as has been proposed in the case of some of the species in Europe. Through the kindness of M. Filhol, I possess jaws of a number of the species found by himself and others in the Phosphorites of Central France, including the *Canis velaunus*, the type of the genus *Cynodon* of Aymard. These agree very nearly with the species of dogs from the American Miocene beds as to generic characters. Professor Owen, in the paper above cited, proposed to distinguish the genus *Galecynus* on account of the greater length of the pollex as compared with that found in the existing species of *Canis*. This character appears to me to be of an unsatisfactory nature, owing to the fact that gradations in the length of a digit are difficult to express with precision in other than a specific sense; and the gradations may certainly be expected to occur.

I find in the *G. geismarianus* a character which separates the genus from *Canis*, viz, the presence of the epitrochlear foramen of the humerus. In this point it agrees with *Amphicyon* and *Temnocyon*. I ar-

range cotemporary and generally similar species under the same generic head, as the most reasonable course in the absence of direct evidence.

The American species of *Galecynus*, then, may be arranged as follows:

I. Smaller species with little or no sagittal crest.
  * Temporal ridges uniting close behind orbits; otic bullæ small.
    Small; no external ridge on inferior sectorial ..... *G. gregarius* Cope.
  ** Temporal ridges uniting early; otic bullæ large.
    Larger; no external ridge on inferior sectorial; teeth robust.
      G. geismarianus Cope.
    Smaller; an external ridge on lower sectorial; teeth more robust.
      G. latidens Cope sp. nov.
  ** Temporal ridges not uniting anteriorly; otic bullæ large.
    Least; muzzle narrow; superior tuberculars wide; no external ridge on inferior sectorial ..... *G. lemur* Cope.

HYÆNOCYON Cope.

Paleontological Bulletin, No. 31, 1879, p. 3 (Dec. 24); Proceedings American Philosophical Society, 1879, p. 372.

This genus rests on the characters furnished by a single species, which is represented by but few remains. Its family position is doubtful, and my reference of it to the *Canidæ* is only provisional. It may, so far as the evidence goes, be a member of the *Mustilidæ* or even of the *Felidæ*.

Dental formula: I. $\frac{?}{3}$; C. $\frac{1}{1}$; Pm. $\frac{4}{3}$; M. $\frac{1}{?1}$. Last superior molar rather narrow, transverse. Inferior premolars all two-rooted, and with well-developed posterior cutting lobe. Inferior sectorial large, with heel. Probably no inferior tubercular tooth.

The characters above given agree with those of *Icticyon* in the superior series, but differ in the inferior in the absence of the Pm. I. and the M. II.

The only known species is the *Hyænocyon basilatus* (*Enhydrocyon basilatus* Cope olim.), from the Truckee beds of Oregon.

ICTICYON Lund.

Kongl. Danske Vidensk. Selsk. Afhandl. naturvidensk. og math. Classe, ix, Deel, 1842 (October, 1841) fide Burmeister; Van der Hoeven Wissen. en natuurk. Verh. der Koninkl. Akademie Amsterdam, Deel iii; Burmeister Erlauterungen zur Naturgesch. Brasiliens, 1856, 2.—*Cynalicus* Gray, Ann. Magaz. Nat. Hist. London, xvii, no. 112, 293.—*Melictis* Schinz. Revue et Magaz. de Zoologie, 1848, 176, fide Burmeister.

The dental formula is, I, $\frac{3}{3}$; C. $\frac{1}{2}$; Pm. $\frac{4}{4}$; M. $\frac{1}{2}$. The single superior tubercular molar is similar in general to that of other *Canidæ*. The inferior sectiorial has an internal cusp and posterior heel, the latter with a low cutting edge on one side. Inferior tubercular well developed. One existing and one extinct species have been found in Brazil, the latter in the caves. I described a species from the Miocene which I cannot separate from them generically. This is the *Icticyon crassivultus* Cope (Proceedings Academy Philadelphia, 1879, p. 190).

Art. VIII.—On the Vertebrata of the Wind River Eocene Beds of Wyoming.

By E. D. Cope.

The Wind River, the principal source of the Big Horn, rises in the Wind River Mountains, in Western Central Wyoming, and flows through a bad-land region for a hundred miles. This region was explored by Dr. F. V. Hayden in 1858, who makes the following observations respecting it (American Naturalist, 1878, p. 831):

Along the east side of the Wind River Mountains, and filling up the Upper Wind River Valley, is a great thickness of Tertiary strata that has been weathered into very remarkable forms, and which are known in the West as "bad lands". The strata are most beautifully variegated with various shades of pink or brick-red color, so that they sometimes remind one of the Jura-Trias red beds. This formation was described by me in 1859 in detail, and named the Wind River group. It covers a broad area in this region, extending from the source of Wind River to the Sweet Water Mountains, south, more than one hundred miles, and west an average width of one to five miles. The aggregate thickness of this group cannot be less than 5,000 feet. On the west side of the Wind River Mountains no formations older than the Wasatch group are found. This group rests, doubtless, on the Archæan nucleus, inclining at the base 5 to 10 degrees. All the older sedimentary rocks have been entirely swept away from the granites for a distance of 100 miles; while on the opposite or east side, all the corresponding strata are visible, from the Silurian to the Cretaceous The Wasatch beds cover a large part of the Green River Valley, especially about its sources.

During the past summer I sent a party into the Wind River Basin, under direction of Mr. J. L. Wortman, already well known from his numerous important paleontological discoveries in Oregon. This gentleman made a thorough exploration of the bad lands, and probably obtained all the fossils found on the surface in the region. The following list of forty-five species shows that the collection embraces nearly all of the characteristic types of the American Eocene, and that twenty-six species are new to science. Among the most remarkable of these I may cite the large flesh-eater *Protopsalis tigrinus*, the largest of the Eocene period yet known, and the Amblypod, *Bathyopsis fissidens*, an important addition to the forms of that peculiar order.

Mr. Wortman's explorations were not accomplished without accident, he having lost most of his outfit on his first crossing of the Wind River. The bad lands form a most forbidding region, mostly waterless, and at an elevation which is unfavorable to the sparse vegetation which is permitted by the dryness of the climate.

PISCES.

1. CLASTES sp.
Scales of this genus are moderately abundant.

2. PAPPICHTHYS sp.
Vertebræ of this genus occur in the collection.

LACERTILIA.

3. PLACOSAURUS.
A species probably of this genus is not rare; and vertebræ indicat two or three species of lizards.

TESTUDINATA.

Tortoises are not abundant; a portion of the plastron of a specie probably of—

4. DERMATEMYS—
Being the only determinable fragment procured by Mr. Wortman.

CROCODILIA.

5. CROCODILUS sp.
Not very common.

RODENTIA.

6. PLESIARCTOMYS BUCCATUS Cope.
Three individuals.

7. PLESIARCTOMYS DELICATISSIMUS Leidy.
Four individuals.

8. PLESIARCTOMYS DELICATIOR Leidy.
Eight individuals.

CHIROPTERA.

9. VESPERUGO ANEMOPHILUS Cope.
American Naturalist, 1880, p. 745.

Represented by the anterior part of a skull without lower jaw. Den tition: I.?; C. 1; Pm. 2; M. 3. Posterior molar narrow, its posterio external V rudimental; first and second molars subequal. Fourth premolar elevated and acute, with an external basal cingulum; second premolar simple, acute. Profile steeply elevated behind orbital region less steep in front of it; zygomas wide. Length from interorbital regio to above canine alveolus in front, .010; interorbital width, .005; width of zygomas, .012; width between outsides of last molar teeth, .010; length of molar series, .008; length of true molars, .004.

BUNOTHERIA.

TÆNIODONTA.

10. CALAMODON CYLINDRIFER sp. nov.

The only individual of this species discovered by Mr. Wortman i represented by fragments of the jaws, with several teeth, both loos

and imbedded in matrix. The former show that the molars have but one root. The latter include the large rodent-like incisors in a fragmentary condition, and a nearly complete tooth intermediate in character between the flat-banded teeth and the molar teeth of the known species of *Calamodon*. It may occupy an intermediate position in the jaw, but I do not know of any appropriate place for it in the mandible of *Calamodon arcamœnus*. I think there is little doubt the individual belongs to a species with narrower teeth than any of those of the two species already named.

The characteristic tooth in question is nearly cylindric, and the part preserved is quite long and slender. Its grinding surface is worn concavely, as in the flat teeth of the known species of *Calamodon*. The enamel is in two bands, one wider than the other, and each of equal width throughout. The space of cementum separating them on one side is nearly twice as wide as that on the other. The cementum layer is not so thick as in the species of the genus hitherto described. The shaft of the tooth is slightly curved, and the wider band of cementum is on the inner side of the curve.

Measurements.

	M.
Width of enamel of large incisor	.018
Length of shaft of cylindric tooth	.041
Diameters of grinding surface of cylindric tooth { antero-posterior	.011
Diameters of grinding surface of cylindric tooth { transverse	.010

INSECTIVORA.

11. ESTHONYX ACUTIDENS sp. nov.

The largest species of the genus, and represented by two individuals. The first of these includes the last molars of both series and an anterior true molar; the second includes most of the dentition of one maxillary bone, the last true molar being probably the only tooth missing. Four of the molars of this specimen are in place, and three are loose. Under the circumstances, I estimate seven molars, of which the fourth premolar is like the first true molar, and the third premolar has its internal lobe very much reduced. The two preceding premolars have one root, and short, compressed, and acute crowns. The second is abruptly very much smaller than the third, and is close to it; the first is close to the second, and is a little larger. The canine is larger still, and is somewhat compressed. Externally viewed, it looks like the canine of a carnivorous mammal; but viewed from within, it displays marked peculiarities. It has here a median rib, separated from the fore and aft edges of the crown by a groove. This ridge is without enamel, and the edges are produced and very sharp. The enamel of the external face extends twice as far towards the base as on the interior side. The enamel of this tooth, with that of the premolars, is wrinkled; that of the molars is smoother.

The details of the inferior teeth preserved do not differ much from those of the *E. bisulcatus*, excepting that the heel of the last true molar is much more produced.

The *E. acutidens* is considerably larger than either of the species of the genus heretofore described.

Measurements.

No. 1.

		M.
Diameters of last inferior molar	vertical	.0065
	anteroposterior	.0130
	transverse	.0064
Diameters of a true molar	anteroposterior	.0095
	transverse	.0074
Diameters of last superior molar	anteroposterior	.0097
	transverse	.0130

No. 2.

Length of five superior molars preserved		.0410
Length of premolar series		.0325
Length of bases of Pm. I and II		.0125
Diameters of Pm. III	anteroposterior	.0097
	transverse	.0098
Diameters of first true molar	anteroposterior	.0086
	transverse	.0133
Anteroposterior width of base of crown of canine		.0080
Transverse width of base of crown of canine		.0050

12. ESTHONYX SPATULARIUS Cope.

American Naturalist, 1880 (Nov. 25), p. 908.

Represented by five molar and premolar and two incisor or canine teeth, apparently belonging to one individual. These are about the size of those of *E. bisulcatus*, but present several differences of detail. Thus, the basin of the heel of the last inferior molar is not obliquely cut off by a crest which extends forwards from the heel, but is surrounded by an elevated border, which rises into a cusp on the external side. The incisor-canine teeth are more robust than those of *E. bisulcatus*, one of them especially having a spoon-shaped crown, with the concave side divided by a longitudinal rib, on which the enamel is very thin. The enamel descends much further down on the external than the internal side of these teeth. The rodent-like tooth does not accompany the specimen. Length of base of last inferior molar, .009; width anteriorly, .005; length of crown of canine-incisor No. 1, .009; width at base, .005; length of crown of second canine-incisor at base, .012; width, .006.

MESODONTA.

13. HYOPSODUS PAULUS Leidy.

Numerous specimens.

14. HYOPSODUS VICARIUS Cope.

Less abundant.

15. PELYCODUS JARROVII Cope.

A jaw fragment supporting the last two molars presents the characters and dimensions of this species. The genus *Pelycodus* differs from *Tomitherium* in that the second premolar resembles the later ones in having two roots instead of having but one root like the first, as is found in the latter genus.

16. PELYCODUS TUTUS Cope.

Tomitherium tutum Cope, Report Expl. Surv. W. of 100th Mer. under Capt. Wheeler, iv, pt. ii, p. 141.

Represented by numerous specimens.

17. PELYCODUS NUNIENUM sp. nov.

Fragmentary jaws of six individuals of this species were found by Mr. Wortman. They indicate a species intermediate in dimensions between the *P. tutus* and *P. frugivorus*, which is further defined by the form of the last inferior molar.

The best preserved ramus supports all the teeth posterior to and including the third premolar. The last-mentioned tooth has an elevated acute crown, without any anterior basal tubercle, and a very short posterior heel. The fourth premolar is very stout; its cusps are not much elevated, and the heel is short. The anterior basal tubercle is quite small. All of the true molars have a second cusp in front of the anterior interval, but it is quite small, excepting on the first, where it is more distinct. The external crescents of all the molars are well defined, but the posterior does not inclose the crown behind with an extension of its horn. The last molar is a little longer than the others, and its posterior border is produced into two cusps. A simple raised border is found here as in *P. frugivorus*.

Measurements.

		M.
Length of molar series from third premolar, inclusive		.0228
Length of true molars		.0150
Diameters of first true molar	anteroposterior	.0050
	transverse	.0038
Diameters of last true molar	anteroposterior	.0065
	transverse	.0040
Depth of ramus at Pm. III		.0095
Depth of ramus at last true molar		.0095

18. PANTOLESTES SECANS sp. nov.

Represented by the adherent rami of a mandible, on both of which the posterior four molar teeth are preserved.

The species is about the size of the *P. chacensis*, and hence larger than the *P. longicaudus*. It differs from both in the proportions of its teeth, and especially in the large size and sectorial character of the fourth premolar. The length of the latter exceeds a little that of the third true molar, while in the other species it is shorter. This length is caused by the extent of the anterior basal tubercle and posterior heel. The latter

is entirely surrounded by a cingulum, and its median line is elevated into a blade, which is continuous with the posterior edge of the principal cusp. Both edges of the anterior tubercle are also trenchant. The two cusps of the anterior inner tubercle of the first and fourth molars are well developed, but on the second molar there is but one cusp. This is probably a character to be relied on in distinguishing the species from the *P. chacensis*. No external basal cingula; enamel smooth.

Measurements.

	M.
Length of last four molars	.021
Length of fourth premolar	.006
Elevation of fourth premolar	.004
Length of last true molar	.005
Depth of ramus at first true molar	.007

As is the case with the species of *Pantolestes* already known, the *P. secans* seems to have been rare.

19. MICROSYOPS SPEIRIANUS Cope.

American Naturalist, 1879, p. 908.

Established on a portion of a mandibular ramus which contains the three true molars in perfect preservation. As the number of premolar teeth is unknown, its reference to this genus is provisional only. The last true molar has the form of that of the *M. gracilis* Leidy. It is distinguished by its very small size, since it is considerably less than the *H. vicarius* (*H.? minusculus*), and by the equality in size of the molars. The heel of the third molar is very small, and the two cones of the inner side of the crowns of all the molars are acute. The external crescent are very well defined, the anterior sending a horn round the anterior extremity of the crown. The posterior is connected with the corresponding internal tubercle by a median conic posterior tubercle. Length of true molar series, .008; length of second molar, .0026; width of second molar, .0022; length of last true molar, .0025; width of last true molar, .0016; depth of ramus at second molar, .0043. Dedicated to my friend Mr. Francis Speir, of Princeton, N. J., who, in connection with Messrs. Scott and Osborne, has made important additions to our knowledge of the Eocene *Vertebrata*.

20. MICROSYOPS GRACILIS Leidy.

Represented by numerous jaws.

21. MICROSYOPS SCOTTIANUS sp. nov.

A nearly entire left mandibular ramus is all that I have seen of this species. The crowns of the fourth and sixth molars furnish the only dental characters available, but the number and forms of the bases of the others are readily ascertainable.

The ramus of the jaw is more slender than in *M. gracilis*, and the last true molar has quite a different form. Instead of being shorter than it

llied species, this tooth is rather longer, evidently in consequence of a ell-developed heel. The fourth premolar has a strong inner tubercle, nd no anterior cusp or cingulum. Its heel has an elevated posterior order, enclosing a fossa with the principal cusps. No external or inter- al cingula. Third premolar with two roots. Alveolus of the second, rge and apparently simple; it is filled with matrix. Canine large, irected forwards, and occupying all the space between a short dias- ma and the symphysis. The latter extends posteriorly to below the nterior part of the third premolar. The ramus is compressed and aintains an equal depth to the end of the molar series. Its inferior order descends below the coronoid process, and is not incurved, but ie external face is convex. The anterior masseteric ridge is well arked, descending to below the middle of the ramus. Masseteric ssa flat. Mental foramen below the third premolar.

Measurements.

	M.
ength of the fragment of ramus	.0435
ength of dental series without incisors	.0280
iameters of canine { antero-posterior	.0040
iameters of canine { transverse	.0025
ength of premolar series	.0100
ength of fourth premolar	.0040
idth of fourth premolar behind	.0027
ength of true molar series	.0136
ength of last true molar	.0052
idth of last true molar anteriorly	.0030
epth of ramus at third premolar	.0090
epth of ramus at last molar	.0090

This species is dedicated to my friend Prof. William B. Scott, of the ollege of New Jersey.

CREODONTA.

?. Miacis canavus sp. nov.

Established on the mandibular rami of two individuals, which display e roots and some of the crowns of all the teeth exclusive of the in- sors.

The root of the canine indicates that the crown is of large size and mpressed at the base. The first premolar is one-rooted, and is sepa- ted from the second by a short diastema. The second has two well- stinguished roots, which are separated from those of the third by a dias- ma like that in front of them. Posterior to this there are no diastemata. ie second root of the fourth premolar is much larger than the anterior. ie sectorial, though the largest tooth, is of but moderate dimensions; heel supports two posterior tubercles. The first tubercular is a lit- shorter. It has a raised border, and the anterior part two angu- tubercles. The second tubercular is a very small tooth, but has two ots, the posterior of which is posterior to the anterior border of the cending ramus.

According to Leidy's measurements, this species is about the size of his *M. vorax* of the Bridger formation. That species has, like the two others of that horizon, a second tubercular tooth with only one root.

Measurements.

	M.
Length of dental line posterior to canines	.0440
Length of premolar series	.0250
Length of base of fourth premolar	.0065
Length of base of sectorial	.0085
Length of base of first tubercular	.0060
Length of base of second tubercular	.0040
Depth of ramus at second premolar	.0150
Depth of ramus at second true molar	.0100

This species was probably about the size of the gray fox.

23. MIACIS BREVIROSTRIS sp. nov.

This species differs from those of the Bridger epoch in the same way that *M. canavus* does, *i. e.*, in the biadicate last inferior molar. Its dimensions are intermediate between those of *M. edax* and *M. vorax*, hence a little smaller than those of the *M. canavus*. This difference is partially seen in the shortening of the premolar series of teeth. They are closer together than in the *M. canavus*, and the roots are larger. The sectorial tooth is shorter. The fourth premolar has a low anterior basal cingulum; the posterior part of the crown is robust. The first tubercular molar is wide, and consists of a basin-shaped heel and a short anterior portion which is more elevated. The latter consists of two cusps, which are connected by an anteriorly convex ledge, but there is no third anterior tubercle as in *M. parvivorus*. The ramus is quite robust, and the basis of the canine tooth is unusually large. Mental foramina are below the anterior parts of the second and fourth premolars, respectively. Last inferior molar small.

Measurements.

	M.
Length of molar series	.0380
Length of premolars	.0200
Length of base of fourth premolar	.0060
Length of base of sectorial	.0072
Length of base of first tubercular	.0048
Length of base of second tubercular	.0042
Depth of ramus at second premolar	.0140
Depth of ramus at second true molar	.0140

24. DIDYMICTIS ALTIDENS Cope.

American Naturalist, 1880, Oct. p. 746.

Represented by several specimens. The species is larger than the *D. protenus*, or about equal to the coyote; but the tubercular molar is relatively smaller, and has the three anterior cusps better developed. The heel of the tubercular sectorial is longer and the three cusps more

elevated than in *D. protenus*. Diameters of latter tooth: Length antero-posteriorly, .015; length of heel, .006; elevation of external side of crown anteriorly, .015; width at same point, .009. Length of crown of tubercular, .009; width of same, .006; elevation anteriorly, .005.

25. DIDYMICTIS LEPTOMYLUS Cope.

American Naturalist, 1880, Dec. p. 908.

Represented by the posterior three inferior molars. These indicate a species of smaller size than the *D. protenus*, with the tubercular molar relatively narrower, and perhaps longer. The anterior part of the latter has the three cusps well defined and close together, and behind them is an oblique longitudinal cutting edge. The middle of the posterior margin rises into a tubercle. The anterior cusps of the tubercular sectorial are elevated; the heel has a strong external cutting edge and internal ledge. Length of tubercular sectorial, .009; width of same, .005; length of tubercular, .007; width of same in front,

26. DIDYMICTIS DAWKINSIANUS sp. nov.

This flesh-eater is represented by more or less imperfect mandibular rami of three individuals. The most complete of these lacks only the portions posterior to the coronoid process, and those anterior to the first premolar, and supports all the teeth excepting the first and second premolars. The premolars are all two-rooted excepting the first. The base of the fourth premolar is considerably longer than that of the third. Both of these teeth have a short posterior heel, and above it a cutting lobe. The fourth has a well-marked anterior basal tubercle. The heel of the sectorial is relatively short, and the anterior portion of the tooth elevated. The anterior and inner cusps are high, and about equal, but the external cusp is much higher. The external border of the heel is more elevated than the inner. The tubercular molar is elongate, and has a small triangular anterior portion somewhat elevated, in slight resemblance to the sectorial tooth. This portion consists of two opposite cusps and a lower one in front of the anterior inner, which connects with the external by an anterior ledge. The posterior portion has a tubercle on the external side, besides a posterior elevation. The ramus is rather slender, and the masseteric fossa is bounded by a prominent ridge in front, but fades out below.

The measurements show this to be the smallest species of the genus, being much less than the *D. leptomylus*.

Measurements.

	M.
Length of dental series, including first premolar	.0265
Length of premolar series	.0168
Length of base of fourth premolar	.0055
Length of base of sectorial	.0053
Width of base of sectorial at middle	.0035
Elevation of sectorial	.0055

	M.
Length of first true molar	.0044
Width of first true molar in front	.0028
Elevation of first true molar in front	.0025
Depth of ramus at second premolar	.0064
Depth of ramus at tubercular molar	.0070

This species is dedicated to my friend Prof. W. Boyd Dawkins, the distinguished geologist and paleontologist, of Manchester, England.

27. STYPOLOPHUS STRENUUS Cope.

Portions of two individuals, with lower jaws, etc.

28. ICTOPS BICUSPIS Cope.

Stypolophus bicuspis Cope, American Naturalist, 1880, Oct. p. 746.

The genus *Ictops* was determined by Leidy from a species, the *I. dakotensis* Leidy, from the White River formation. The animal now mentioned is identical with it in generic characters, so far as they are ascertained. The *I. dakotensis* is established on a specimen which does not contain all the teeth, but the parts preserved indicate that those which are wanting are like the corresponding parts of *Leptictis* Leidy and *Mesodectes* Cope, with which the present species also agrees. It is unexpected to identify a genus found on the White River horizon with one from the Wasatch. *Ictops* agrees very closely with *Didelphys*. The fourth superior premolar has an internal cusp, which is wanting in *Didelphys*, and the inferior border of the mandible is not inflected. There are also but three superior incisors on each side. Under these circumstances I prefer to refer this genus to the *Bunotheria* rather than to the *Marsupialia*, but whether its proper place is in the Creodont or Insectivorous subdivisions I cannot yet determine.

Char. specif.—Smaller than the *Stypolophus minor* Filh., and not very different in dimensions from the *Ictops dakotensis* Leidy. It is represented by a nearly complete skull, with entire dentition of both jaws. Premaxillary bones rather elongate; general form of skull that of a civet. Crowns of second and third superior premolars compressed, with a prominent cusp behind the principal one. First and second true molars with two distinct external cusps and a strong external basal cingulum. Inferior first premolar one-rooted, third with a posterior heel, and fourth with strong anterior and especially posterior heels. Heels of true molars well developed (last broken). Length of superior dental series to I. 1, .031; length of molar series, .020; length of true molars, .006; depth of mandible at second true molar, .007; depth at canine, .0035. The double-lobed third premolar and the smaller size distinguish this species from the *Stypolophi*.

29. ICTOPS DIDELPHOIDES sp. nov.

Established on a left mandibular ramus, which supports the last three molars. This demonstrates the former existence of a species of larger

ize than any of the *Leptictidæ* hitherto known. The general form of the inferior true molars is a good deal like that of *Stypholophus*, but they may be distinguished by three characters in which they at the same time, agree with the *Ictops bicuspis:* First, the elevated border of the heel, with a strong external cusp and weaker posterior and internal elevations; second, the small development of the anterior cusp; third, the posterior production of the heel of the third true molar, giving an indication of a fifth lobe. The external anterior cusp of the third molar is elevated; on the first molar it is less so, and the anterior cusp is small. The enamel is smooth, and there are no internal nor external cingula. The mandibular ramus is compressed and deep.

Measurements.

		M.
Length of bases of three true molars		.0165
Diameters of first true molar	anteroposterior	.0055
	transverse behind	.0038
Diameters of last true molar	anteroposterior	.0060
	transverse	.0050
Depth of ramus at anterior root of last true molar		.0095

The jaw fragment described indicates a skull about the size of that of the common opossum.

10. PROTOPSALIS TIGRINUS Cope.

American Naturalist, 1880, p. 745.

Char. gen.—Probably *Oxyænidæ*,* but as the type species is only known from two true molars and a canine of the inferior series, with bones of the skeleton, this point remains to be ascertained. Femur with a weak third trochanter. Inferior molars: one like those of *Oxyæna*, *i. e.*, with large heel and internal cusp; another, probably the last, larger, without internal tubercle, and with a rudimental heel, thus resembling the inferior sectorial of various existing *Carnivora*.

Char. specif.—Size about that of the tiger or jaguar, exceeding that of any other flesh-eater of the Wasatch epoch. The heel of the smaller tubercular-sectorial is not large, and has a plano-concave superior surface. The principal cusp is much elevated, while the internal cusp is small. The sectorial differs from that of a *Hyæna* in having the posterior cusp more, and the anterior cusp less elevated; the heel is only a strong posterior cingulum, which is continued as a narrow line along the inner base of the tooth. A rough cutting ridge forms the posterior inner angle of the principal cusp. There is a wide longitudinal groove of the inner face of the inferior canine, whose enamel surface is impressed-punctate. The shaft of the femur is nearly straight. Diameters of crown of sectorial, anteroposterior, .025; transverse, .014; vertical, .022; length of heel of tubercular-sectorial, .006; width of same, .006; vertical diameter of base of crown of canine, .022; depth of mandible at last molar, .044; length of femur (condyles inferential), .100; diameter of shaft at middle, .034.

* See Proceed. Amer. Philos. Soc. 1880, July.

AMBLYPODA.

PANTODONTA.

31. CORYPHODON CUSPIDATUS Cope.

Part of the dentition of one individual.

32. CORYPHODON RADIANS Cope.

Apparently an abundant species.

DINOCERATA.

33. BATHYOPSIS FISSIDENS gen. et sp. nov.

Char. gen.—These can only be given as seen in the mandible, t only part of the skeleton in my possession. Dentition: I. 3; C. 1; P 4; M. 3. Incisors, canine, and first premolar forming an uninterrupt series, which is separated by a diastema from the molar series. T molar and premolar teeth are constructed on an identical pattern, pr senting slight modifications from front to rear. This consists of an a terior elevated transverse crest, and a posterior heel with raised post rior border; between these is situated on the external side an elevat cusp, which sends a low ridge inwards and forwards. The inner e tremity of the anterior crest is cusp-like, and is accompanied by a secon internal anterior cusp immediately posterior to it. The mandibul ramus has great vertical depth, its inferior border being convex dow wards throughout its entire length. Symphysis coössified.

The above characters indicate a new genus of considerable interes Its form differs from that of the two genera where it is known, vi *Uintatherium* and *Loxolophodon*, in the much greater development of th inferior expansion. In *Loxolophodon* it has been shown by Messr. Speir and Osborne to be represented by a mere convexity. In *Uint therium* Marsh has discovered it to be confined to the anterior part of th jaw, as in the sabre-tooth cats. In *Bathyopsis* it extends to the enti length of the ramus, giving an outline in profile much like that of *Meg therium*. The anterior extremity of the symphysis projects beyond th line of the anterior border of the inferior expansion.

The characters of the inferior molars in this and other genera of *Din cerata* are very peculiar. In *Bathyopsis* they are constructed on the pla of those of insectivorous marsupial and placental mammals, so as to lea to the suspicion that its food consisted of crustacea, or insects of larg size, or possibly of thin-shelled mollusca.

Char. specif.—This species was probably about the size of the Malaya tapir. The symphysis mandibuli is quite narrow, and its superior exca vation is deep. It extends as far posteriorly as the middle of the dias tema. It has considerable vertical thickness. The anterior edges o the lateral expansions are truncate, and present an obtuse angle out wards, which forms the anterior boundaries of the slight concavity of th lateral face. The middle of the expansion below the first premolar toot is slightly convex. This wall encloses a large internal expansion of th

ental canal, which issues in a large mental foramen. This foramen is situated near the middle of the vertical diameter of the expansion, and below the anterior part of the diastema. It looks downwards and forwards. The external face of the posterior part of the ramus is nearly plane. The inner face is vertical to a line which corresponds with the inferior border in *Coryphodon*, and then slopes obliquely outwards to the inferior margin. The base of the coronoid process rises vertically from the line of the alveolar border, and its external edge forms an anterior border for the masseteric fossa. The inferior border of the fossa is not defined. The inferior border of the ramus is decurved posteriorly, and projects inwards considerably beyond the plane of the jaw.

The premolars differ from the molars in having all their diameters excepting the vertical, reduced. The fourth premolar only differs from the first true molar in the less elevation of the posterior border of the heel, and in a little smaller transverse diameter. The external part of the heel of the last molar rises into an obtuse cusp; the remainder of the border is tubercular. The heels of the other true molars end in simple recurved transverse edges. On the premolars their posterior extremities are not recurved. The anterior face of the anterior cross-crest of all the molars is concave, and on the second premolar it looks obliquely inwards. The posterior or second anterior inner cusp is obsolete on the second premolar. The enamel on all of these teeth is, excepting where worn, rather finely wrinkled. The first premolar is not preserved, but its alveolus indicates that it is one-rooted and rather robust. The sizes of the alveoli of the other anterior teeth are arranged in the following order, commencing with the largest: C.; I.2; I.3. The alveolus of the canine is compressed, and has more than twice the anteroposterior diameter of the largest incisor. The alveoli of the first and third are subround; that of the second is somewhat compressed.

Measurements.

		M.
Length from the middle of the second incisive alveolus to the extremity of the last molar		.1950
Length of the series of consecutive molars		.1170
Length of diastema		.0240
Diameter of alveolus of Pm. I		.0090
Diameter of alveolus of canine		.0250
Length of premolars		.0460
Diameters of Pm. II.	vertical	.0130
	anteroposterior	.0130
	transverse	.0090
Diameters of Pm. IV	vertical	.0120
	anteroposterior	.0105
	transverse	.0120
Diameters of M. I.	vertical	.0100
	anteroposterior	.0155
	transverse	.0110
Diameters of M. III.	vertical	.0176
	anteroposterior	.0260
	transverse	.0180

The appearance of the ridges of the anterior part of the jaw of the *Bathyopsis fissidens*, together with the remarkably large dental canal and mental foramen, strongly suggest that the animal possessed a large and perhaps prehensile lower lip.

PERISSODACTYLA.

34. PALÆOSYOPS BOREALIS Cope.

American Naturalist, 1880, p. 746.

Founded on a portion of the right maxillary bone, which supports the three true molars and one premolar. Size of *Limnohyus fontinalis*, or much smaller than *P. lævidens*. Anterior median tubercle well developed; anterior and posterior cingula strong, not rising to inner cones. A low ridge extending outwards and forwards from posterior cone. Enamel smooth. Differs from *P. junior* Leidy in the presence of the intermediate tubercle and crest, and in the weak external cingulum. Length of true molar series, .063; diameters of first true molar, anteroposterior, .019; transverse, .020.

Portions of several individuals were obtained by Mr. Wortman.

35. LAMBDOTHERIUM POPOAGICUM Cope.

American Naturalist, 1880, p. 748.

Char. gen.—Dentition much as in *Limnohyus*, excepting that there is a diastema in front of the second inferior premolar. Presence of first inferior premolar not ascertained. Fourth inferior premolar without posterior cusps. Superior molars with an angular ridge extending inwards from each inner cusp. Last inferior molar with heel. This genus differs from *Oligotomus* in the simplicity of the fourth premolar, which has in the latter two posterior cusps. The V-shaped crests of the inferior molars separate it from *Hyracotherium*.

Char. specif.—The heels of the second and third premolars have a median keel; the third only has an anterior tubercle. The crest of the heel of the fourth forms an imperfect V. Heel of the last true molar small. No cingula; enamel smooth. Length of molar series, .080; of true molars, .044; of last molar, .019; depth of ramus at first premolar, .021; at last molar, .031. Second specimen: Diameters of crown of last superior molar, anteroposterior, .014; transverse, .016. About the size of the *Hyrachyus agrestis*.

This species was probably the most abundant perissodactyle of the epoch of deposit of the Wind River beds.

36. LAMBDOTHERIUM BROWNIANUM sp. nov.

Considerably larger than the *L. popoagicum*, and about equal to the *Tapirus terrestris*. The greater part of a lower jaw represents the species, and on this unfortunately only one of the premolar teeth remains. The three premolars are all two-rooted, and the posterior lobe of the last true molar is well developed. The inferior part of the exter-

ial side of the ramus contracts or retreats rather abruptly posteriorly, below the last molar. It presents a slight external convexity below the second and third premolars. The alveolar line rises rapidly posteriorly, so that the last true molar is quite oblique. The second (first) premolar has a considerable heel, which is narrow and elevated on the middle line. The principal cusp is large and compressed, but obtuse, and has no anterior basal tubercle.

Measurements.

		M.
Length of six molars		.090
Length of true molars		.055
Diameters second (first) premolar	vertical	.009
	anteroposterior	.012
	transverse	.006
Length of base of first true molar		.015
Width of base of first true molar		.009
Length of base of third true molar		.023
Width of base of third true molar		.011
Depth of ramus at second premolar		.030
Depth of ramus at M. III	at front of tooth	.039
	at end of tooth	.047

Dedicated to my friend Arthur E. Brown, superintendent of the Philadelphia Zoölogical Garden.

7. PACHYNOLOPHUS CALCICULUS COPE.

Lophiodon calciculus Cope.

American Naturalist, 1880, p. 747.

Represented by lower jaws of two specimens. Transverse crests of inferior molars not connected by oblique ridges. Last true molar with a very small tubercle-like heel. A weak external basal cingulum; enamel smooth. Third and fourth premolars with wide heels, each with a single low ridge. Length of molar series, .053; of true molars, .033; of last true molar, .014; depth of ramus at penultimate molar, .025; diameters of penultimate superior molar at No. 2, antero-posterior, .012, transverse, .014.

This species is referred to *Pachynolophus* from its analogy to the *P. ventorum* in most respects.

8. PACHYNOLOPHUS VENTORUM Cope.

Lophiodon ventorum Cope, American Naturalist, 1880, p. 747.

Larger than the last, and differing in having a large heel of the last true molar, and an elevated external tubercle on the heel of the fourth premolar. Enamel wrinkled; no external cingulum. Second premolar with a very short heel with an acute tubercle. Length of molar series, .064; of true molars, .040; of last true molar, .016; depth of ramus at second premolar, .020; at third true molar, .030. Seven individuals in the collection, one with complete series of maxillary teeth. These in-

clude four premolars (the first one-rooted), so that the formula M. $\frac{4}{3}\frac{3}{3}$ is that of *Pachynolophus* Pom. rather than of *Lophiodon*. I refer another species to the same genus, by analogy, as it agrees in the dentition of the inferior jaw.

39. HYRACOTHERIUM ANGUSTIDENS Cope.

Apparently an abundant species. There are three sizes which I refer here, which may represent different species, but this cannot be determined without better material:

A. Depth of ramus at last premolar or first true molar, .0120; length of crown of first true molar, .0070; length of last true molar, .0100. Lower jaw of one specimen.

B. Depth of ramus, .0140; length of first true molar, .0065; of last molar, .0100. One lower jaw.

C. Depth of ramus, .0155; length of first true molar, .0075; of last true molar, .0100. Two individuals.

Portions of lower jaws of three other individuals in the collection are apparently referable to the *H. angustidens*.

40. HYRACOTHERIUM VENTICOLUM sp. nov.

Hyracotherium vasacciense Cope, American Naturalist, 1880, p. 747; not Report Expl. Surv. W. of 100th Mer. iv, p. 264.

Represented by an entire skull, with some bones of the skeleton, of one individual.

In general, this species is to be distinguished from its near ally, the *H. vasacciense*, by the slender mandibular ramus. The depth of this bone is about equal to that found in the larger varieties of the *H. angustidens*, but the teeth are much larger, having the proportions of those of the *H. vasacciense*. This remark applies especially to the last inferior molar.

The inferior canines form part of an uninterrupted series with the incisors. The superior canine is separated from the superior incisors by a diastema. The first premolar in both jaws is isolated. The second superior premolars have two cusps, and an internal ledge posteriorly. The third and fourth superior premolars are similar, the fourth displaying a little larger transverse diameter. The true molars are of subequal dimensions. Their external cusps are subconic. All the molars except the first and second premolars are entirely surrounded by a basal cingulum, which rises into a low cusp at the anterior external angle of the crown. The third inferior premolar has its two median cusps well separated and a wide posterior heel. The heel of the last premolar is wider, but carries no internal cusp. The external cusps on all the teeth wear into well-defined Vs. The posterior five molars have an external basal cingulum, but no other.

The mandibular ramus is compressed. The ascending ramus rises almost vertically a short distance posterior to the last molar. The symphysis is narrow, and extends to below the middle of the first premolar. The infraorbital foramen opens above.

Measurements.

		M.
ngth of consecutive superior molars		.04500
ngth of diastema between Pm. I and II		.00350
ngth of second premolar		.00700
idth of second premolar posteriorly		.00500
ameters fourth premolar	anteroposterior	.00700
	transverse	.00900
ameters second true molar	anteroposterior	.00850
	transverse	.01120
ngth of entire inferior premolar series		.05800
ngth of entire inferior true molar		.00282
ameters first true molar	anteroposterior	.00800
	transverse	.00600
ameters last true molar	anteroposterior	.01200
	transverse	.00650
pth of ramus at fourth premolar		.01650
pth of ramus at third true molar in front		.01650

The lower jaw of a second individual agrees with the type in its proportions.

. HYRACOTHERIUM CRASPEDOTUM Cope.

American Naturalist, 1880, p. 747.

Size of *H. tapirinum*, but the tubercles of the inferior molars are not nnected by cross-crests, and they all possess a strong external basal ngulum, which also extends round on the posterior base of the I and II ıe molars. Heel of fourth premolar with a diagonal ridge; two ante- or cusps well separated, and no tubercle in front of them. Second emolar with narrow heel; last true premolar with wide heel. Length molar series, .056; of true molars, .033; of last molar, .014; depth of mus at second premolar, .018; at last true molar, .023.

This is the largest species of the genus found in the Wind River beds. arts of two individuals were obtained by Mr. Wortman.

. OROTHERIUM VINTANUM ("Marsh") Cope.

Report Expl. Surv. W. of 100th Mer. iv, p. 255.

A portion of the mandible of a single specimen, containing the characristic fourth premolar and other teeth.

ARTIODACTYLA.

A species of this order is represented by an astragalus. This is the st indubitable evidence of the existence of this order during the asatch epoch that I have seen. The following species are referred re provisionally only, as no part of their skeletons is known.

. PHENACODUS VORTMANI Cope.

Hyracotherium vortmani, American Naturalist, 1880, p. 747.

This species is represented by portions of mandibles of four individls. One of these supports the posterior four molars, another the posrior two, and another the last premolar and first true molar.

These indicate an animal of much smaller size than the *P. primævus*, but with a similar constitution of the molar teeth. The teeth support four conic cusps, which do not incline to fuse transversely, as is generally the case in *Hyracotherium*. Those of the posterior pair are separated by a tubercle, and a rudimental tubercle stands behind the notch between those of the anterior pair. The posterior median tubercle is developed into a heel on the last molar. On prolonged wear, the resulting pattern represents two Vs, the posterior limb of the posterior being regularly convex backwards. There are no cingula on any of the molars. The ramus is rather robust and is not deep.

Measurements.

No. 1.

	M.
Length of bases of posterior five molars	.0440
Length of bases of true molars	.0250
Depth of ramus at Pm. III	.0160
Depth of ramus at M. III in front	.0190

No. 2.

Diameters of M. II	anteroposterior	.0080
	transverse	.0070
Diameters of M. III	anteroposterior	.0080
	transverse	.0055

The characters of the typical specimen are as follows: The jaw fragment indicates an animal of about the size of the *Hyracotherium craspedotum*, but with the opposite cones of the inferior molars not united by cross-crests. There is a tubercle between the posterior pair of the first inferior true molar. The anterior tubercles of the fourth premolar are close together, and there is a strong cusp anterior to these. No basal cingulum on this tooth. Length of molars 3 + 4 + 5, .025; depth of ramus at Pm. IV, .018.

44. PHENACODUS PRIMÆVUS Cope.

A fragment of a lower jaw, with teeth.

45. PHENACODUS TRILOBATUS Cope sp. nov.

A lower-jaw fragment, supporting the three true molars, of one individual, represents this species. It is of the dimensions of the *P. primævus*, and displays the same general constitution of the teeth. The only difference noticeable is an important one. The anterior internal tubercle is accompanied by two others of less elevation—the one immediately anterior, the other immediately posterior to and not deeply separated from it. The internal face of these tubercles slopes obliquely outwards on the second and third true molars. The external tubercles have their external faces sloping inwards on all the true molars. There are no cingula.

Measurements.

		M.
Length of true molar series		.0390
Diameters of first true molar	anteroposterior	.0107
	transverse	.0097
Diameters of third true molar	anteroposterior	.0130
	transverse in front	.0100

GENERAL OBSERVATIONS.

Until the faunæ of the Wasatch and Bridger epochs are better known it will not be possible to fix the relation which that of the Wind River beds holds to them. It is, however, quite evident that in some respects it differs from both, both by what it possesses and what it lacks. In the following lists these differences are displayed so far as they relate to genera. The left-hand column represents the Wasatch, the middle the Wind River, and the right hand the Bridger.

Wasatch.	Wind River.	Bridger.
Clastes	*Clastes.*	*Clastes.*
	Pappichthys.	*Pappichthys.*
Crocodilus.	*Crocodilus.*	*Crocodilus.*
Plesiarctomys.	*Plesiarctomys.*	*Plesiarctomys.*
		Myops.
	Vesperugo.	*?Vesperugo.*
Calamodon.	*Calamodon.*	
Esthonyx.	*Esthonyx.*	
Ectoganus.		
		Anchippodus.
	Ictops.	*?Ictops.*
		Mesonyx.
	Miacis.	*Miacis.*
Didymictis.	*Didymictis.*	?
Oxyæna.		?
Pachyæna.		?
	Protopsalis.	?
Stypolophus.	*Stypolophus.*	*Stypolophus.*
	Microsyops.	*Microsyops.*
Pantolestes.	*Pantolestes.*	*Pantolestes.*
Pelycodus.	*Pelycodus.*	?
		Tomitherium.
		Anaptomorphus.
Coryphodon.	*Coryphodon.*	
	Bathyopsis.	
		Uintatherium.
	Palæosyops.	*Palæosyops.*
	Lambdotherium.	?
?Pachynolophus.	*Pachynolophus.*	
Hyracotherium.	*Hyracotherium.*	?
Orotherium.	*Orotherium.*	?
		Hyrachyus.
Phenacodus.	*Phenacodus.*	

From the above it is evident that the Wind River fauna includes genera which have been hitherto restricted to either the Wasatch or Bridger lists. Of these, especially Bridger genera, there are six; that is, six genera which have not yet been detected in beds of the Wasatch epoch. On the other hand, there are nine genera which have been found in Wasatch beds and not in those of the Bridger. Three important Wasatch genera have not been found in the Wind River formation, while seven of the characteristic genera of the Bridger are not included in the list of those of the Wind River. The result, imperfect as it is, indicates a considerably greater conformity to the Wasatch epoch than to the Bridger in the faunal characters of the Wind River beds, and points to the confirmation of Dr. Hayden's views as to the identity of the two epochs.

The new species above described will be fully illustrated in the fourth volume of the Report of the United States Geological Survey of the Territories, F. V. Hayden in charge, now passing through the press.

On the Crocodilian genus PEROSUCHUS.

BY EDWARD D. COPE.

Characters.—Toes 5–4, with claws two—three. No osseous nasal septum or bony eyelid. Belly protected by series of osseous plates, as well as the back.

All the genera of Crocodiles hitherto known as living are characterized by the possession of three claws on the fore foot. The present therefore offers a remarkable exception. The free fingers and half webbed toes, and the bony abdominal buckler, together with the cartilaginous nasal septum are points of strong resemblance to Jacare (Gray, including *Cieman* Gray), but it differs from these creatures in the lack of bony orbital plate. In specific characters it differs from those of this genus, which it most resembles, as J. n i g r a, in the absence of a transverse bony ridge between the orbits. Another feature of importance is the relation of the canine teeth of the lower jaw to the upper. On one side this tooth is received into a notch, as in Crocodiles, on the others it enters a pit of the maxillary bone, within the border of the same, as in Alligators! This remarkable combination may be abnormal even in this species, but this cannot be now ascertained, as it rests at the present time on a single specimen only. As its affinities are rather more alligatorial, I am disposed to anticipate that the dental arrangement of the latter type will be most common.

PEROSUCHUS FUSCUS Cope.

Char. specificus.—Nuchal plates in a cross row of six; cervicals in four cross-rows, all of four plates except the last of two. Dorsal plates six—in a few eight in each transverse row. No posterior crest on arm or leg. Tail short with remarkably low crest. Muzzle broad, flat, without any ridges; its width at the eighth tooth entering 1·4 in length from end of muzzle to anterior margin of orbit.

Description.—The specimen in the Museum of the Academy is young, measuring only 2 feet 5 inches in length. Of this the skull measures to the margin of the supra-occipital 2 in. 10 5 lin.; and the tail from the vent 13 in. 1 line. From groin to heel 3 in. 2·5 lines, and the hind foot 2 in. 7·5 lines. The muzzle is a broad ovate, the sides rather more convergent anteriorly than in the Alligator m i s s i s s i p p i e n s i s. There is a thickening in front of each orbit, and between them on the middle line another, which together enclose two shallow concavities. Superciliary margins raised, the cranial table quite flat. The margin of the quadrato-jugal bone projects strongly. The scales of the limbs are all smooth and those of the dorsal region with very low keels. The sides have four longitudinal rows of ovate scales separated by scarcely defined smaller ones. The abdominal plates are longer than broad, and are in twelve longitudinal rows. Dorsals in seventeen transverse series from interscapular to crural region. The lateral crests of the tail are only obtuse keels; they unite on the thirteenth annulus behind the vent inclusive. Color above dark brown, almost black on the upper surface of the head. The tail is paler, of a light olive brown. Lower surface everywhere bright yellow, including the entire lower jaw and margin of the upper. Eyelids and a band through ear yellow, the former with a black spot above.

Remarks.—This interesting addition to our knowledge of the Reptilia was made by Schuite Buckow, of New York, while on a visit to the interior part of the course of the Magdelena River, in New Grenada. This naturalist has also enriched our collections with other interesting vertebrata of that region, both living and dead.

Sept. 1*st.*

The President, Dr. Hays, in the Chair.

Twenty-two members present.

Sept. 8*th.*

The President, Dr. Hays, in the Chair.

Twenty-eight members present.

Sept. 15*th.*

The President, Dr. Hays, in the Chair.

Twenty-eight members present.

The following papers were presented for publication:

Extinct Mammalia of Dakota and Nebraska, including an account of some allied forms from other localities, together with a synopsis of the Mammalian Remains of North America. Illustrated by twenty-eight plates. By Joseph Leidy, M. D. Preceded by an introduction on the Geology of the Tertiary Formations of Dakota and Nebraska, accompanied by a Map. By F. V. Hayden, M. D.

Notice of American Species of Ptychodus. By Joseph Leidy, M. D.

Synopsis of the Extinct Batrachia of North America. By Edw. D. Cope.

Dr. Leidy read a letter from Mr. B. Waterhouse Hawkins, proposing to erect in the Museum, at his own expense, the fossil remains of the Hadrosaurus to their natural relations in the figure of that great Dinosaur, in accordance with Dr. Leidy's descriptions in his Monograph of the Cretaceous Reptiles of the United States.

On leave being granted, the following resolutions, offered by Dr. J. L. LeConte, were adopted:

That the Academy accept the proposition of Mr. B. Waterhouse Hawkins, to erect in this Hall, at his own expense, a restoration of the skeleton Hadrosaurus.

That the thanks of the Academy be respectfully tendered to Mr. Hawkins for his liberal offer, and that the Curators be instructed to furnish to him every facility in the use of specimens in the Museum, which the most liberal interpretration of the By-Laws will permit.

Sept. 22*d.*

Dr. Bridges, in the Chair.

Twenty-four members present.

Sept. 29*th.*

The President, Dr. Hays, in the Chair.

Twenty-four members present.

Dr. D. G. Brinton was elected a member.

On favorable report of the Committee, the paper of Dr. Leidy, presented Sept. 15th, entitled "Extinct Mammalia of Dakota and Nebraska," etc., reported in favor of its publication in the Journal.

On favorable report of the Committees, the following papers were ordered to be printed:

Notice of American Species of PTYCHODUS.

BY JOSEPH LEIDY, M. D.

The Cestraciont genus of fishes Ptychodus, so far as known, is confined to the Cretaceous Formations. Remains, consisting of teeth, I have had the opportunity of inspecting from Alabama, Mississippi and Kansas, and although reported to exist in the Cretaceous Formation of Delaware, I have not met with them from that locality nor from the Green Sand, of corresponding age, of New Jersey. The following list comprises all the specimens of American Ptychodus teeth I have had the opportunity of examining.

PTYCHODUS MORTONI.

Agassiz, Poissons Fossiles III. (1833-43), 158, Tab. 25, figs. 1—3; copied in figs. 773, 773a, of Dana's Manual of Geology.

Palate bone of a fish ? Morton: Syn. Org. Rem. Cret. Group. (1834), pl. xviii, figs. 1, 2.

The teeth of *Ptychodus Mortoni* I have seen only from the cretaceous formation of Alabama and Mississippi. Morton, in the work above noticed, figures a tooth, but does not mention the locality from which it was obtained.

Agassiz, in his Poissons Fossiles, gives a good representation of a tooth of this species, from the Green Sand of America, in three views, figs. 1—3, Tab. 25.

Dixon, in his Geology of Sussex, represents two small teeth, (figs. 6, 7, pl. xxi), which he refers to the same species. Though exhibiting some resemblance in character to the American teeth, I think a further comparison is necessary to establish their specific identity.

The teeth of *Ptychodus Mortoni* are well defined in character, and in comparison with teeth of well recognized European species are almost generic in their peculiarity. Though exhibiting some variety, their likeness presents a distinct specific uniformity. Their size of course varies greatly with age and the relative position they occupied with one another in the mouth of the fish.

Viewed from above, the crown is reniform in outline, the long diameter being transverse; the incurvature posterior. The crown rises in the form of a cone with a more or less obtuse summit. The sides of the crown slope to the base and frequently more or less abruptly expand, laterally approaching the latter. The back part is occupied by a wide triangular sinus for the reception of the fore-part of the crown of the tooth which was situated in front of it when the teeth were contained within the mouth. The border of the crown is thick and rounded and dips beneath. At the sinus it is prominent. The summit of the crown presents a prominent crucial ridge, more or less distinct in different specimens. From the cross numerous ridges of about the same thickness diverge upon the sides of the cone, branching in their course, multiplying and becoming finer, and ultimately conjoining upon the base in a fine reticulation extending to the borders of the crown. The coarser ridges vary in their proportionate length in different specimens. The reticulation of the base is most extensive laterally, occupying usually half the breadth of the space between the summit and border. It also occupies the sinus, and is least developed at the fore-part of the crown. The width of the crown approaches double the

fore and aft measurement, and the height is usually little less than the latter. The root partakes of the form of the outline of the base of the crown, but is more square and is flat or transversely concave below.

Twelve specimens of teeth of *Ptychodus Mortoni*, from the Cretaceous Formation of Alabama, belonging to the Yale College Museum, have been submitted to my examination by Mr. William M. Gabb. Among them occurs the largest tooth of the species I have seen, and larger than any on record. It is labelled as having been derived from Perry Co., Alabama. The fang and parts of the lateral and back borders of the crown are broken away. In the perfect condition the crown has measured a little over two inches in transverse diameter, one inch and a quarter antero-posteriorly, and ten lines in height. The crushing surface is porportionately less prominent at the centre than in the smaller teeth attributed to the same species, and is more uniformly convex, or less expanded laterally at the base. The borders of the posterior sinus also are less abrupt or defined. The unworn summit presents a crucial ridge, of which the lateral radii are most distinct and directed postero-laterally. From the crucial ridge, numerous ridges, equally prominent, diverge, branch in their course and ultimately conjoin in a fine reticulation at the base af the crown. This reticulation has the greatest breadth at the sides of the crown and is least developed at the fore-part.

Eleven teeth from Uniontown, Alabama, exhibit a gradation in size from less than three-fourths that of the above described specimen down to one little more than a fourth of its diameter. The specimens present a remarkable similitude throughout. Some are proportionately wider fore and aft than others, and the smallest are porportionately higher than the largest ones. The outline of the base of the crown is reniform, with the relation of the longer and shorter diameters varying. The largest specimen has the crown an inch and a half wide, a little over three-fourths of an inch fore and aft, and about half an inch in height. The sides of the crown expand at the base laterally; the fore-part forms nearly a uniform slope, and the back surface slopes to the sinus, which forms a broad triangular depression. The fang is fourteen lines wide, seven lines fore and aft, and three lines in depth.

The crown of a median sized tooth of the series, unworn, measures scant 14 lines wide, $7\frac{1}{2}$ fore and aft, and $6\frac{1}{2}$ high. The smallest specimen has the crown 7 lines wide, $4\frac{1}{2}$ fore and aft, and an equal height. Its base laterally appears more abruptly expanded than in the others. Most of the specimens are unworn and exhibit the characteristic ridges of the crown in a striking manner. In three specimens the coarser ridges are resolved into the reticulation much earlier or nearer the summit than in the others. In one specimen the crown is smooth or totally devoid of ridges, presenting the same appearance represented in figs. 4, 5, pl. xxx, of Dixon's Geology of Sussex, and described as "nascent or incomplete teeth of *Ptychodus*.

Seven specimens of teeth in the Museum of the Academy, from Alabama, exhibit the same characters expressed in the description of those above. They all present an unmistakeable specific likeness, though varying in the proportions of their diameter. The largest specimen has the crown 16 lines wide, 11 lines fore and aft, and 8 lines high. The root is an inch wide, 7 lines fore and aft and nearly 3 lines thick. A second specimen, with the crown 16 lines wide and 9 lines fore and aft, has been proportionately lower than the former. Its summit is worn away, leaving an exposed circular disk of vaso-dentine 4 lines in diameter.

Two specimens in the Museum of the Academy, presented by Prof. Joseph Jones, are from Green Co., Alabama. The larger is perfect and unworn. The crown is scant 14 lines wide, by 7 lines fore and aft, and 5 lines high. The root is $11\frac{1}{2}$ lines wide, $4\frac{1}{2}$ fore and aft, and 2 lines thick.

Two specimens in the Museum of the Academy, presented by Dr. Wm. Spillman, are from Columbus, Mississippi. They present the same character as the Alabama specimens. The larger specimen has the crown 20 lines wide, 10 lines

fore and aft, and has perhaps been about 8 lines high. The summit is worn off, leaving an exposed flat circular surface of vaso-dentine half an inch in diameter. The root is 15 lines wide, 6 lines fore and aft, and three lines thick. The smaller specimen consists of an unworn crown 11½ lines wide, 7 lines fore and aft and 5½ lines high.

PTYCHODUS OCCIDENTALIS, n. s.

The Museum of the Academy contains a specimen consisting of the crown of a tooth of a species of *Ptychodus* differing from any other previously known. It was obtained by Dr. John L. LeConte, in association with other remains of fishes, from an ash-colored rock of the Cretaceous series, a few miles east of Fort Hays, Kansas.

The tooth is remarkable, especially from the comparatively near approximation of its diameters, the width transversely and fore and aft and the height approaching one another more nearly than in any other species. The fore-part of the crown is somewhat injured and the root is broken away. The transverse diameter of the crown at base is 14 lines; the fore and aft diameter has been about an inch; and the height is also an inch.

In shape the crown is a blunt cone with the sides sloping evenly to the base and to the posterior sinus. The latter is a triangular concavity about two-thirds of the breadth in height.

The direction and arrangement of the ridges of the crown are much like as in the European *Ptychodus decurrens*, but the principal ridges crossing the crown transversely are finer and the intervals much narrower, indeed the space occupied by a pair of ridges with their interval in *P. decurrens* would accommodate three ridges with a pair of intervals in *P. occidentalis*. Descending the sides of the cone the ridges branch as in *P. Mortoni*, and at the basal half of the crown form a reticulation much as in *P. decurrens*. At the back of the summit of the crown the principal ridges continue their transverse or parallel course until near the upper part of the sinus, into which as they descend they are resolved into a fine reticulation. The fore-part of the crown is occupied by a reticulation formed by the descent, convergence and division of the more anterior principal ridges.

From the description it will be observed that the tooth holds an intermediate position in anatomical character to those of *Ptychodus Mortoni*, and *P. decurrens*.

Three small teeth, found by Dr. Le Conte in association with the latter, resemble, in their proportions and in the proportionate size and arrangement of the ridges of the crown, the teeth of *P. decurrens*, but perhaps may belong to the same species as the large tooth above described. The larger of the three specimens is perfect, but has the summit of its crown worn off. The crown measures 7 lines transversely, 6 lines fore and aft, and has been from 4 to 5 lines high. The root is 6 lines wide, 4½ lines fore and aft, and 2½ lines thick. Comparatively coarse ridges cross the crown transversely, curving forward laterally and ending in a marginal reticulation. Branching ridges descend in front from the foremost of the transverse ridges, and likewise end in a marginal reticulation. The sinus is occupied by a finer reticulation joined by fine ridges descending from the summit and sides of the crown. The smallest tooth, likewise perfect, has the crown 4½ lines wide, 3½ lines fore and aft, and 2½ lines high.

Three additional specimens associated with the former ones, are the smallest teeth of *Ptychodus* I have seen, but I suspect that they belong to the same species. They are transversely ellipsoidal in outline at the base of the crown, and this appears as a low cone elevated at the inner third and with a broad expanding base. The sinus is situated at the inner posterior third. The surface of the crown is crossed with transverse ridges which form a narrow reticulation at the border. The largest of these small specimens is 3⅓ lines transversely, 1¾ fore and aft, and ¾ of a line high from the root. The smallest tooth is 2¼ lines wide, 1½ fore and aft, and ½ a line from the root.

PTYCHODUS POLYGYRUS.

Agassiz: Poissons Fossiles III, 156; Dixon: Geology of Sussex, 1850, 363. Gibbes: Jour. Acad. Nat. Sci., 1849, 299, pl. 42, figs. 5, 6.

Dr. Gibbes, in the work above noticed, figures two teeth, from the cretaceous formation of Alabama, which he refers to *Ptychodus polygyrus*. They clearly bear a close likeness to specimens of the European species of that name.

A single specimen of a tooth, accompanying the Alabama specimens belonging to the Yale College collection, resembles the teeth of the European *Ptychodus polygyrus*. The crown is nearly square or transversely oblong, with the fore and back borders nearly straight, and the lateral borders convex. The crushing surface is moderately convex and is crossed transversely by ten coarse acute ridges, separated by similar intervals. The borders of the surface, including the posterior sinus, are occupied by comparatively fine vermicular and interrupted ridges, appearing like granulations. The coarse ridges are nearly straight, and at the end rather abruptly resolve themselves into the finer vermicular ridges of the border. From European specimens of the teeth of *P. polygyrus* and *P. latissimus*, this tooth appears especially to differ in the proportionately greater degree of fineness of the bordering vermicular ridges or granulations of the crown. Its measurements are as follows:

Width of crown 13 lines; fore and aft 11 lines; height 5½ lines; width of fang 8 lines; fore and aft 6½ lines; thickness 3 lines.

Of other species of *Ptychodus*, Agassiz mentions teeth of *P. mammillaris*, found in the excavation of the Delaware canal, and preserved in the Museum at Paris. (Pois. Fos. III, 151.) I have seen no specimens of that species from an American locality.

Synopsis of the Extinct BATRACHIA of North America.

BY EDWARD D. COPE, A.M.

BATRACHIA.

The vomer is double, and usually bears teeth in this class; the premaxillary is usually double; Amphiuma and Spelerpes b e l i i are exceptions. Teeth never planted in deep alveoli.

There are six orders, as follows:

TRACHYSTOMATA.

Caudal vertebræ and frontal bones distinct.

Inferior pelvic elements not confluent.

O. o. maxillaria, prefrontalia, palatina and pterygoidea wanting; nasalia present.

Ethmoid,* two lateral pieces, each forming part of palate.

Mandible toothless, condyloid.

No "postorbital and supertemporal bones."

First pair ceratohyals distinct.

PROTEIDA.

Caudal vertebræ and frontal bones distinct.

Inferior pelvic elements not confluent.

O o. maxillaria, prefrontalia and nasalia wanting; palatina and pterygoidea present.

Ethmoid,* a vertical plate on each side the cerebral lobes.

Mandible toothed, teeth pleurodont.†

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*Erroneously called orbitosphenoids by me, Jour. Acad. 1866 (on Anura).

†The statement made by Dr. Gray that the teeth of Necturus are canaled, as in venemous serpents, by a channel entering at the base and issuing below the tip, appears to the writer to be of doubtful accuracy. No other opening exists in the teeth of Necturus m a-

Ceratohyals, first pair connate.
No postorbital and supertemporal bones.

URODELA.

Usual cranial bones present, but pterygoids reduced or wanting.
No "postorbital or supertemporal bones."
Caudal vertebræ and frontal bones distinct.
Ethmoid a vertical plate on each side.
Mandible dentigerous, teeth pleurodont.
Inferior pelvic elements horizontal, in contact, no osseous pubis; ilium suspended to a sacral rib.
(Mostly no quadratojugal.)

GYMNOPHIDIA.

Usual cranial bones present and distinct, including frontals and pterygoids.
Caudal vertebræ distinct.
No "postorbital or supertemporal bones."*
Ethmoid an annulus surrounding cerebral lobes.
Mandible dentigerous; teeth anchylosed by their bases.†
(A quadratojugal.)

STEGOCEPHALI.

Usual cranial elements distinct, including frontals and pterygoids, and adding "postorbitals and supertemporals."
Caudal vertebræ?
Ethmoid normal.
Inferior pelvic elements distinct.
Mandible dentigerous; teeth with anchylosed bases, or
(A quadrato-jugal.)

ANURA.

Frontal and parietal confluent, nasals wanting or rudimental; other cranial bones present.
Postorbital, supratemporal and usually nasals wanting.
Ethmoid an annulus (usually complete above) surrounding cerebral lobes.
Caudal vertebræ represented by an elongate compound style.
Inferior elements of the pelvis consolidated into a single vertical mass; ilium attached immediately to sacral vertebra.
Quadratojugal.

STEGOCEPHALI.

XENORHACHIA.

The vertebral centra not ossified; ? the dentition pleurodont; teeth simple; ? no branchial hyal bones. ? Occipital condyles.

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culatus than the emargination at the base of the root occupied by the growing crown of the successional tooth, as in other Batrachia. If the structure described by Dr. Gray exists, it is in a species as yet unexamined by American zoologists. Professor Winchell, of Ann Arbor, confirms my observation.

In my Synopsis of higher groups of Batrachia (Journ. Acad. Nat. Sci. 1866), I stated that Amphiuma possesses minute scales. Gray, in 1850 (Catalogue Brit. Mus.), makes the same statement, which Duméril (1863. Catal. Mus. Paris) contradicts. I must accord with Prof. Duméril, since a subsequent examination has convinced me that they do not exist. The specimen in which the appearance of scales was presented was mislaid at the time of writing, and I find it was due to numerous free portions of the true derm, which are continuous with the attached portions.

*When the temporal fossa is overarched it is by expansion of the maxillary and quadratojugal. (Stannius says "squama temporalis.")

†The teeth of Cæcilia are compressed with a trenchant posterior edge, which is crenate, after the manner of Megalosaurus, Carcharias, etc. Thus to the numerous genera of Saurians and Selachians possessing this character, must be added a Batrachian.

MICROSAURIA.

Vertebral centra ossified; no branchial hyoids; teeth simple or with slightly inflected enamel, pleurodont. Occipital condyles.

GANOCEPHALA.

Vertebral centra cartilaginous; branchial hyoids present; teeth with slightly inflected enamel, anchylosed by their bases. No ossified occipital condyles.

LABYRINTHODONTIA vera.

Vertebral centra osseous; no branchial hyoids; teeth with much inflected enamel, anchylosed by their bases. Occipital condyles.

XENORHACHIA.

This order I proposed for the reception of the genus Amphibamus Cope, in 1865. I proposed to regard, as one of its characters, the existence of opisthocœlian vertebræ. Such impressions were observed in the matrix in which the fossil was preserved, as to induce a belief in the existence of such vertebræ, and the existence of these in a well ossified condition, in the apparently nearly allied genus Pelion Wyman, strengthened such belief. There were actually, however, only osseous neural arches present, and I am now decidedly of the opinion that the vertebral centra were either cartilaginous or annuliform, as in Archegosaurus.

AMPHIBAMUS Cope.

Proc. Acad. Nat. Sci. Phila. 1865, 134.

AMPHIBAMUS GRANDICEPS Cope, Proc. Ac. N. Sci. Phila. 1865, p. 134. Palæontology Ill. State Survey. Tab.
Carboniferous; Lower Coal Measures, Morris Co., Illinois.

MICROSAURIA.

This sub-order was established by Prof. Dawson, for small lizard-like vertebrates from the Coal Measures, which he thought presented points of affinity to, or should be under the Saurian reptiles, at the same time recognizing Batrachian characteristics.

After examining the evidence brought forward by Prof. Dawson, it appears to the writer that the Saurian characteristics are analogical only, and not indicative of true affinity, and that these creatures form, in fact, a series closely resembling or parallel with what was probably an immature stage of the Labyrinthodontia. They are in fact Labyrinthodonts, with simple or very slightly inflected enamel of the teeth, and with the extent of the exostosis of the cranial bones much reduced. This character has been much overrated by some authors. In the Dendrerpeton o b t u s u m Cope the grooving and pitting exists only on the posterior parts of the cranium, and gradually disappears anteriorly. In the Alligator m i s s i s s i p p i e n s i s the same is the case.

The points in which they have been said to resemble the Lacertilia, are, 1st, the dermal scales; 2d, the parietal fontanelle; 3d, possession of ribs. All of these features belong to the Labyrinthodontia; the Xenorhachia also had scales. On the other hand, the two occipital condyles, indicating the existence of a parasphenoid bone, distinguishes it at once from all the Allantoid vertebrata, and the form of the vertebræ is very Batrachian. In the Lacertilian families of Gecconidæ and Hatteriidæ only we have biconcave vertebræ, but the concavities are comparatively shallow, and the vertebræ less constricted medially than in the Microsauria. Those of the latter are much like those of Salamanders, according to Prof. Dawson's figures.

The bones figured as pelvic are unlike those of any Batrachia or Lacertilia known to the writer. But until those of the Labyrinthodontia are discovered,

we cannot assert that they differ from the latter. The long spatuliform elements figured as pelvic are, perhaps, scapulæ, which are of not very different type in the Trachystomata, Proteida, and the Ganocephala.

The only species included in this tribe in which inflections of the enamel have been described, is the Dendrerpeton acadianum, and here it is only at the base. It is, however, not impossible that this genus should not be associated with Hylerpeton, Oestocephalus, etc. The genera Urocordylus, Cerathrpeton, Lepterpeton, Ophiderpeton and others recently described by Prof. Huxley, also belong here.

PELION Wyman.

In litteris. *Raniceps* Wyman, Amer. Jour. Sci. Arts, 1858, 158. Not of Cuvier (Pediculati).

Pelion lyellii Wyman. *Raniceps lyellii* Wyman, l. c.

This animal differs from the genus Amphibamus in the well-ossified vertebral axis; no remains of a tail with elevated neural spines exist in the type specimen, and no ventral scales are seen in it.

Middle Coal Measures, Jefferson Co., Eastern Ohio.

HYLONOMUS Dawson.

Hylonomus lyellii Dawson, loc. cit. viii, 167.

The Joggins. Nova Scotia Coal Measures.

Hylonomus aciedentatus Dawson, l. c. viii, 258.

Coal Measures; with the last.

Hylonomus wymanii Dawson l. c. viii, 270.

Coal Measures, Nova Scotia; with the last.

PARIOSTEGUS Cope.

This genus is represented by a large part of the cranium of a Batrachian from the triassic coal measures of Chatham Co., North Carolina. If not a Batrachian, it could only belong to a ganoid fish, but though some of its characters are somewhat ichthyic, it lacks the following important elements of the ganoid structure, i. e., free post- and suborbital bones; postnareal cavities; branchiostegal, and arched branchihyal bones. On the other hand it has a large preorbital, bounding the frontal and maxillary to the nares, and the inner border of the orbit, as in Stegocephalous Batrachia; also a postorbital element contributing to the formation of an extended supratemporal roof.

Contrary to what has been found the case in most genera of Stegocephali, the maxillary appears to extend posteriorly to a free termination, as in modern Salamanders, and the supra-temporal bone presents a very prominent, obtuse, arched margin. This margin extends from the orbits on each side, and is incurved towards the posterior part of the cranium. There is therefore no quadratojugal piece.

The maxillary and mandibular pieces are slender, flat bones, as in Menopoma; the form of the posterior or articular portion of the latter cannot be ascertained from the specimen. The more or less exposed part of the median region of the latter exhibits a succession of shallow transverse notches, enclosing thirteen obtuse elevations. The former resemble rudimental lateral alveolæ for minute pleurodont teeth. A few other similar minute ribs, and perhaps a minute curved cone without sculpture, are the only other indications of dentition.

The bones of the upper surface of the cranium are most readily interpreted by reference to those of Menopoma. A pair of narrow nasals, acuminate behind, penetrate between the frontals as far posteriorly as the posterior margins of the orbits. The suture between these is very distinct, and entirely straight. The preorbitals extend to above the orbits, and there appear to cease with a transverse suture. Between these and the nasals a broad triangular element enters

on each side, not attaining the probable position of the nostrils. Each is divided by a longitudinal groove, which is probably a suture, and which would then divide the frontals from the parietals. The frontals would then divide the parietals entirely, as they do in Menopoma for the anterior half of their length. This would give the frontals a narrow form, acuminate in front, and bounded behind by a regular coarse, zig-zag transverse suture. The cranium behind this point is rugose, and the surface not well preserved, and it can only be said that two irregular grooves converge to a point between the posterior extremities of the frontals, like the boundaries of the supraoccipital. The posterior boundary of the cranium with the condyles cannot be readily determined. When the postorbital roof bone is raised up, the meeting of two gular dermal bones, as I interpret them, is seen. One of these is a plate directed backwards and outwards, bearing minute radiating lines on its upper surface. It meets a similar flat plate directed forwards and outwards, with similar lines radiating to the circumference. The inner margins of these plates were not seen.

The orbits are remarkably small, and situated probably near the middle of the longitudinal measurement of the cranium. The external nares are not defined, but symmetrical depressions in the position they usually occupy in Salamanders are distinct.

The general form recalls Menopoma, particularly the necessarily small eyes. A slender curved bone with a slightly dilated and truncate extremity, lying by the cranium in connection with the mandible, is like a branchihyal of that genus. Nevertheless it cannot be positively assigned to this genus, as numerous scales of cycloid fishes are on the same block.

PARIOSTEGUS MYOPS Cope.

The surfaces of the cranial bones are little sculptured; there are small tuberculiform elevations on the parietals and more numerous ones on the preorbitals. The postorbitals show the strongest markings of elongate pits which radiate to their circumference, leaving a smooth obtuse border. The nasals present a series of small warts at a little distance on each side of their common suture, and transverse to it. The surface of the maxillary is marked with longitudional grooves and shallow pits.

No suture separating maxillaries and premaxillaries can be traced with certainty, though the bones of the jaw are interrupted at the usual place of suture, opposite the nostril.

Measurements.

	Lin.
Length of specimen (including mandible)	18
Width between outer convexities postorbitals	17
" " inner borders orbits	11
" of same without preorbitals	8
" of nasals at middle	2·5
" orbit	1·5
Length of frontal nasal premaxillary	11.
" " supposed branchihyal	12.

The name is derived from the roof-like postorbitals with free lateral margin.

Locality.—Coal bed of the Keuper Triassic, Chatham Co., North Carolina. The species was discovered by Prof. Jos. Leidy, who handed it to me for description. It is in the Museum of the Academy of Nat. Sciences of this city.

DENDRERPETON Owen.

Journal Geol. Soc. London, 1853, p. 81.

In the form of the cranium this genus differs from Brachydectes and Ophiderpeton, much as Menopoma does from Amphiuma. Two species appear to have left their remains in the coal measures at Linton, Ohio.

DENDRERPETON OBTUSUM Cope.

This species is known by a partially preserved cranium. The superior surface is exposed, the outlines of the jaws and orbits are well preserved, with the occipital condyles. The os-quadratum is directed obliquely backwards, and the angle of the mandible extends to a line a little behind that of the occipital condyles. The zygomatic arch exists in a position similar to that in which it may be seen in a few genera of Anura, as Discoglossus and Pelobates. It extends downwards and forwards from the suprasquamosal to the maxillary region, but whether it is homologically squamosal or malar, the specimen cannot show. The postorbital is present as well, and with the last, and the supratemporal forms the bony roof of the temporal fossa. A piece which may be the pre- and postfrontals combined, borders the inner superior margin of the orbit; it widens posteriorly, where it has contact with the parietal, etc., and narrows in front. Supra-occipitals form together a broad triangle on the upper plane of the cranium, of less extent than the adjoining supratemporal. The latter elements are pitted, and towards their margins radiate grooved. These sculpturings grow less on the margins of the supratemporal, and the portions of the surface of the more anterior element remaining are so slightly marked as to give the impression that the sculpturing in this species is much less than in others of the genus. A few beaded ridges are all that remain on a few of the parietals and postorbitals; the maxillaries have a slightly stronger sculpture seen in a few spots.

The general form of skull is elongate behind, and much shortened in front of the orbits. The orbits are thus altogether in front of a line equally dividing the cranium transversely, while in the D. acadianum Ow. they are in the middle of the skull. The outline of the muzzle in one species is thin, broad, rounded, as in the Menopoma alleghenien sis, while in the latter it is ovate and produced.

The parietal bones extend to opposite the posterior margins of the orbits, are then gradually contracted and form an acuminate prolongation on each side the wedge-shaped frontals. The prefrontals are thickened on each side the front, behind the external nares. The sutures defining the frontals anteriorly, the nasals, and the premaxillaries behind, cannot be made out. The median longitudinal suture is a marked and zigzag one, and can be seen as far posteriorly as the anterior margin of the orbits. The external nostrils are large and opposite the inner margin of the orbit on each side. This separation of the nares is associated with a greater transverse extent of the premaxillaries than in some of the genera. These have been set with numerous teeth, judging by their small impressions; no larger ones have left traces, and no traces of any on the maxillaries. The teeth of the genera before described are all much larger relatively, indicating still further the diversity between them.

A fragment of mandible remains, but without teeth or external surface. It shows a large internal canal.

Measurements.

	Lines.
Total length cranium	25·5
Width cranium 3 lines behind orbits	24
" between orbits	7·5
" " nares	5·
" " occipital condyles	2·2
" of supraoccipital bones	6
" of right parietal	6
Extent of premaxillaries	8·7
Length orbit	6

From the Coal Measures at Linton, Columbiana Co., Ohio, (West Pennsylvania Basin). Discovered by Dr. John S. Newberry.

Another cranium accompanies the collection which belongs to a species dis-

tinct from the last. The muzzle is not so broadly rounded, and the premaxillary teeth are relatively much larger. The sculpture is more delicate, with the ridges more acute. The orbits and nares are not defined. The maxillary is well preserved for a length of an inch; its teeth are smaller than the premaxillaries; I count four in a line; crown simple conic. External surface of maxillary not very strongly sculptured.

This species cannot be referred to its genus without further material. I therefore do not name it, hoping to avoid the unworthy practice of some, who give *prospective* names—to be applied to other peoples future discoveries, and the like.

DENDRERPETON ACADIANUM Owen, Quart. Journ. Geol. Soc., x, 1853, 81. Dawson loc. cit.

Coal Measures: Joggins of Nova Scotia.

DENDRERPETON OWENII Dawson, Canadian Naturalist and Geologist, viii, 161.

Coal Measures: as the last.

HYLERPETON Owen.

HYLERPETON DAWSONI Owen, Journ. Geol. Soc. Lond., 1862, 241. Dawson, Canadian Naturalist and Geologist, viii, 272.

Carboniferous Coal Measures. The Joggins, Nova Scotia.

BRACHYDECTES Cope.

This genus is indicated by two rami of a mandible, and a portion of a premaxillary only. These, when compared with those of Oestocephalus and Dendrerpeton from the same locality, and with others described by authors, are so much stouter, *i. e.* shorter and more elevated, that they evidently pertained to a genus not hitherto known. The genus further differs from Oestocephalus in having the teeth of equal size to the posterior parts of the series, that is to the base of the elevated coronoid process. The teeth are elongate cylindric cones, with their acute tips turned a little posteriorly. The fractured ones display a large pulp cavity. The three premaxillaries preserved are similar but without curvature of the tips. They do not exhibit striæ or any other sculpture. So far as the remains known go, the genus is nearer Hylerpeton than any other. The latter does not give any indication of the very elevated coronoid process of Brachydectes, though the external portion of the dental bone in that region being lost, little can be said about it. Prof. Owen's plate indicates a ramus whose depth at the last tooth enters 8½ times the total length. In our species this depth enters about five times. There are at least nine teeth in the Nova Scotian species; seven in the present one.

BRACHYDECTES NEWBERRYI Cope.

This species is represented by one nearly perfect ramus mandibuli, one dentary bone, and one premaxillary probably not complete.

The dentary bone appears to have been attached by suture to the articular and angular, as its free margin has very much the outline of that suture in Amphiuma and lizards. The coronoid process would also seem to be a part of the same bone as in Amphiuma and Menopoma, and not composed of a coronoid bone as in lizards. It rises immediately behind the last tooth, and displays no suture.

The lower portion of the dentary is prolonged into an acute angle. This is separated by a deep and wide concavity from the superior posterior prolongation, which is obtuse and rises at once into the coronoid process. Teeth on this dentary seven; the same number is on the preserved ramus; this number I suspect to be complete or nearly so. The teeth terminate at the obvious termination of each ramus, which is it is true slightly obscured. The teeth are the longest of the Microsauria in relation to the depth of the ramus, equalling the largest in Ophiderpeton. They are doubtless exposed, as are some of

those of the last named genus, by the splitting away of the outer parapet of the dentary bone. As no traces of alveoli have been thus rendered visible, I suspect the dentition to have been pleurodont, as in existing Batrachia.

No external surface of the mandible remains, but there are no impressions of sculpture on the matrix. A little external face of the premaxillary displays none.

Measurements.

	Lines.
Preserved length of ramus (imperfect)	11.
Depth at last tooth	2.
Length of exposed tooth	1·7
" dentary	7·5
Depth at coronoid	3·5
" at first tooth	1·3

SAUROPLEURA Cope.

Neural and haemal elements of the caudal vertebræ elongate, distally dilated and grooved, attached by contracted bases. Ventral aspect defended by a series of oblique dermal ribs on each side, which meet anteriorly on the median line. Limbs distinctly developed. Ribs long, well developed. Scales none.

No dermal bones have been discovered, nor are any portions of the cranium known.

This genus is allied to the Urocordylus of Huxley, recently discovered in the coal measures in Leinster, Ireland. It differs only in the presence of elongate lizard-like ribs (whence the name), and in the absence of "oat-shaped scales" of the upper surfaces.

It is a matter of much interest in American palæontology that this remarkable type should be found to occur in our coal measures. It was first announced by Dr. Newberry at the meeting of the American Association for the advancement of Science for 1867 (see Proceedings, p. 144), as a supposed Urocordylus, occurring with Ophiderpeton. He mentioned at the same time the discovery of the ganoid Dinichthys Newb.

The forms discovered by Dr. Newberry have an interesting relation to those of Ireland, such as types of the present period frequently present.

The genera may be thus parallelized; where no representation exists, we may look forward to a future discovery to supply the present want:

Ceraterpeton Huxl.,	represented	by	
Urocordylus Huxl.,	"	"	Sauropleura Cope.
Lepterpeton Huxl.,	"	"	
Dolichosoma Huxl.,	"	"	Molgophis Cope.
Ophiderpeton Huxl.,	"	"	Oestocephalus Cope.
			Brachydectes Cope.
Herpetocephalus Huxl.,	?	?	Dendrerpeton Ow.

Of the American genera, Sauropleura and Oestocephalus exhibit the peculiar ventral dermal armature of Urocordylus and Ophiderpeton, while Molgophis does not possess it, nor Dendrerpeton, if our species truly belongs there.

The museum of Columbia College, New York, contains portions of two species of Sauropleura, but both unfortunately represented by portions only of the vertebral column. These are, though closely resembling the species described by Prof. Huxley, sufficient to demonstrate marked generic distinction. This is further established by the remains of the trunk of a third, and larger species, whose relationships can be shown to lie within this genus. This individual has been spread over a surface of the coal slate, exhibiting ventral armature, dorsal region with ribs, and anterior and posterior limbs. Of skull and caudal vertebræ nothing remains.

The dermal riblets are arranged as in Urocordylus, *i. e.*, in parallel lines directed obliquely forwards and continuous on the median line, forming there a

chevron, directed forwards. The striæ are not so closely placed as in U. pectinatus, but are separated by grooves wider than themselves.

The humerus, ulna, and radius are rather stout, and of a size relative to the body, as in common types of existing Sauria; the ulna and radius separate. There is no carpus, but five well-developed digits have phalanges in the following numbers, commencing on the inside: 3—4—5—6—5. The last phalange of the second is obscured, and it is not positive that the number is as given; it is more probable than that it should have been 3. The outer toe has been more slender than the others; the distal phalanges of all the toes are short conic, as in Salamanders. Thus this form differs much from Amphibamus, where the numbers are 3—3—4—5—4, showing a lower developement of limbs.

The ribs are long and curved, as in Reptiles, and judging by their distances the vertebræ are short; the latter are not well defined, but there is no indication of prominent spines of any kind.

The pelvic bones and portions of those of the hind limbs are present, but so obscure and confused as not to be made out. Enough remains to show that the hind limbs are considerably larger than the anterior.

Sauropleura digitata Cope.

This species had a length of body about equal to that of a fully-grown Chamæleo vulgaris of the largest size, or of a half-grown Menopoma. Thirteen ribs on one, and several on the other side, are preserved; where they terminate, probably at the pelvic region, some small or rudimental ribs project from the two or three first caudals. Three ribs and their interspaces extend over five lines. The humerus is broken, but its length can be clearly made out to be seven lines; it has no condyle, and is dilated at both extremities. The ulna and radius are distinct, truncate, hollow, and dilated at the ends. Length of ulna 5·1 lines, distal width 1·8 lines. Carpus not ossified. The fourth toe is considerably longer than the others, the fifth is next, and reaches the basal third of the antepenult phalange of the fourth; the third is very little shorter; the first is not quite so long as the first two of the third. The bones of the hind limb are not readily distinguished. They are evidently much longer and larger than the anterior; no part of a foot is preserved.

This form is probably allied to Urocordylus. It has relatively much stronger ribs in relation to the vertebræ than we have seen in that genus, and there is no evidence of the existence of the peculiarly formed spines of the vertebræ characterizing the latter. The limbs are relatively much stronger than in Ophiderpeton, and it lacks the peculiar dermal armature of that genus.

Sauropleura pectinata Cope.

This species is represented by portions of the vertebral columns of four individuals. In two of these, vertebral centra are discoverable; in one quite definitely. They are slightly constricted medially, and without ridge or process.

The neural and haemal spines of superior and inferior lines are similar, and in the specimens undistinguishable. The dilated portions form nearly equilateral triangles, which stand on moderately short pedicels. They are weakly ridged, and each ridge is prolonged into a narrow acute tooth, beyond the margin, of which eleven may be counted on one of the best preserved. The longitudinal striæ are terminated near the pedicel by two others, which cross obliquely from each side, and, meeting, present an appearance similar to an overlapping of each margin. The edges of the spines form a continuous line.

As in the other species, there are no indications of other processes, nor of dermal scales.

The smallest of the specimens shows that in front of the region furnished with the peculiar spines described, the body is furnished with a mass of bristle- or hair-like scales. The grooved neural spines are slightly displaced anteriorly, and the bristle-like mass looks like a continuation of their striæ, and it is not easy to find any line of demarkation between them. The serrate spines are

continued further forward on one side than the other. These linear scales were arranged as in other genera, in lines which converge forwards to the median line. They are somewhat obscured in the specimen, but it can be determined that they are continuous on the median line. Whether this is the posterior or anterior portion of the body cannot positively be determined from the specimen; it is, however, most likely the posterior, for near the posterior portion of the striate surface a weak pair of limbs is given off on each side. On the right, a moderately stout ? femur is followed by a broken tibia and fibula, and by five slender, closely appressed metatarsals. The last are about two-fifths as long as the space between them and the femur; beyond them a few slender phalanges are moderately distinctly defined. The tibia is more distinct on the left, but no tarsus or phalanges; some of the metatarsals are preserved here also. Length of limb to end of metatarsals equal to five vertebræ in juxtaposition, measured along the edges of the neural spines. The limb has been slender, especially the hand.

The above specimen enables me to assign, as the ventral armature of this species, a closely packed series of V-shaped grooves, which lie in connection with an obscure vertebral column, on the block containing one of the typical specimens of this species. They are not continuous with any of the series exhibited on other parts of the block; some of these at least are the doublings of the slender animal, and this ventral portion has been displaced. The grooves are perhaps the impressions of hæmapophysial rods, vastly more numerous, however, than the number of vertebræ; perhaps they are rather the dermal armature. Huxley figures a portion of this as on the block with Urocordylus wandesfordii, but does not refer it to its precise relation to the animal. A few well-developed ribs are preserved with this portion,—the only ones I can refer to this species. The vertebræ are partly enclosed in matrix, partly impressions. The neural spines, though expanded antero-posteriorly, are less elevated than in the caudal region, and have left no traces of their characteristic ribs or serration.

The number of spines in the type specimens is six in a half-inch; in the smallest, just described, ten in the same distance. The height of the spine in the former is 1·15 lines.

As the characters of this species are most determinable, I regard it as the type of the genus Sauropleura.

Sauropleura remex Cope.

This species is larger than the S. pectinata, and about equal to the Urocordylus wandesfordii Huxl. The caudal spines differ from both in the greater attenuation of the haemal series, and the presence of a basal lamina on the neural.

It is represented by a portion of the vertebral column three inches in length. In this space may be counted twenty-four vertebræ Such of the latter whose outlines are visible display centra, characteristic of the genus; their terminal concavities conic, with apices meeting medially; zygapophyses present; and their length a little greater than their depth.

The characteristics of the species are the remarkable length and slenderness of the fan-shaped neural and haemal spines, and the absence of an acute serration on their margins. In this species the spines have a laminiform expansion at the base in their planes. In the other species here described these spines are not only relatively broader and more fan-shaped, but they are acutely serrate on the margin and constricted at the base.

In S. remex the dilated neural spines are a little more than three times as long as they are distally wide, while the hæmal spines are a little narrower. The neural spines stand about the middle of the centrum. The basal half is furnished with an anterior ala, which leaves the anterior margin rather abruptly and extends to the next spine in advance. It returns gradually to the centrum and is separated from the articular face of the latter by a notch. A

similar ala exists on the posterior margin of the neural spine, which extends for a shorter distance above the base, and is narrower than the anterior. Each spine presents a median groove on its surface, which extends half way to the base or further; on each side of this are some three other grooves, which extend but a short distance; surface otherwise smooth. The ends of the grooves slightly notch the truncated end of the spine.

The hæmal spines are on the posterior portions of the centra, and in contact with the anterior part of the basis of those succeeding. They are without the dilatations of the neural spines, and are directed rather more obliquely backwards. They are similarly grooved, though without that so distinctly median, seen in the neural series.

Both neural and hæmal spines become larger towards the posterior part of the vertebral column. There appear to be no zygapophyses nor diapophyses, nor rudiments of ribs. The centra are rather stout, and somewhat constricted medially. There are no traces of dermal armature of any kind.

Measurements.

	Lines.
Length of a posterior centrum	1·2
Depth " " "	1·
Length neural spine of adjoining vertebra	4·4
Basal width	1·4
Median width	·9
Distal width	1·1
Length of a more anterior neural spine	4·3
Distal width " " " "	1·5
" anterior hæmal spine	4
" width " "	1·4

From the Coal Measures, the Western Pennsylvania and Ohio Bituminous Basin, at Linton, Columbiana Co., Ohio, near the Ohio River. Prof. J. S. Newberry.

ŒSTOCEPHALUS Cope.

This genus is known from a single species as yet. As before remarked, it represents in many respects the Ophiderpeton of Huxley, and has been alluded to by Dr. Newberry as the same. It, however, differs markedly in the narrow lanceolate form of the head, with probable accompanying peculiarities of detail, and in the presence of limbs, which have not been found in the Irish genus. The form of the head is somewhat nearer that of Lepterpeton Huxl., but the limbs of the American genus have as yet been seen as one pair only, and very small, while in Lepterpeton there are two pairs, which are large. The general form of the body of Oestocephalus is more snake-like.

In more detail, we have an elongate lanceolate head with little or no sculpturing of the external surface of the bones. The angles of the mandibles are much prolonged backwards as in Archegosaurus and frogs, and the well developed ribs commence but a short distance behind the head. The vertebræ are slender, and furnished with well developed diapophyses. A pair of symmetrical bones, whose impressions are seen posterior to the occipital region, look like ceratohyals or small scapulæ, and one of them is continuous with a second piece, which occupies the place of a humerus. A third piece follows, which is probably ulna; no radius or manus is preserved. This then is a rudimental fore limb, situate very close to the head. The skin has been occupied by a great number of closely packed, curved, spine-shaped scales. They have occupied the ventral integument passing from the median line of the belly outwards and posteriorly, having acute tips which may have penetrated the skin on each side; whether such tegumentary spines protected the back cannot now be determined.

Oestocephalus amphiuminus Cope.

This species is represented by the imperfect crania and anterior portions of the bodies of two individuals. They indicate an animal of the average size of the Amphiuma means.

The extremities of the vertebræ are deeply concave, but the centra are so long as to prevent the concavities entering more than one-fifth of the latter, each. The diapophyses are behind the middle, and are broad, curved backwards, and acuminate, as in Amphiuma. The centra have a prominent median line below, with a longitudinal concavity on each side. Five of them a little exceed an inch in length. Neural spines are nowhere visible. The humerus is longer than the scapula and is considerably dilated distally; the scapula slightly dilated at its superior extremity.

The dermal armature commences immediately behind the head, and forms a band of 14 lines in width; measuring across the spine-like scales, in a width of a line, four cylinders may be counted. The external portions are carried backwards, the interior nearly straight, those of the anterior more delicate than the posterior.

The head is wedge-shaped with regularly acuminate sides. The top of the cranium is somewhat broken in the specimen; the portions preserved are smooth, and the longitudinal suture is distinct for a considerable distance. The angle of the mandible is produced considerably behind the occiput and is enlarged and rounded. The end of the muzzle is broken away, and the region of the orbits so fractured as to render their precise location uncertain. The superficial layer of the cranial bones is nowhere clearly visible, so that it cannot be ascertained whether it is sculptured or not. The quadrate bone projects well posteriorly. Some fragments indicate small cylindric teeth, as in Amphibamus, but they are not characteristic.

Measurements.

	Lines.
Length cranium without muzzle	17·3
Width " posteriorly	11·5
Length scapula	2·1
" humerus	2·5
" of sixth vertebra from skull	3
Extent diapophyses	3·5
Width centrum	1·5

This species was discovered by Prof. Jno. S. Newberry, at Linton, Eastern Ohio, in the slate of the coal measures. Mus. Columbia College.

The characters of the genus are further shown by a part of another individual in the same coal slate matrix. The cranium and anterior portion of the vertebral column only are preserved, the latter so much injured as to render the vertebral characters very obscure. As in the other, the bristle-like scales extend along the dorsal region to near the cranium. The anterior two-fifths of the ventral side shows a large number of small oval scale-like bodies, which belonged undoubtedly to the animal and were probably dermal scales. They are, however, neither regular in form or position. Close behind the head two or three long bones of the fore limbs have been exposed. They are slender, and similar to those of the last specimen.

The cranium, though without the muzzle, shows its long wedge-shape. The maxillary bone cannot be distinguished, nor can the orbits be made out; one ramus mandibuli is pretty well preserved; it shows no coronoid process. Twenty-one teeth may be counted on a portion a little more than one-third its length. The anterior eleven of these are abruptly longer and stouter than the others. They are, except a few most anterior, in pairs, *i. e.* with a slight vacancy between every two. The larger ones were broken at the bases, exhibit a moderate pulp cavity; the smaller, a large one extending to near the tip. Several, though not all of the larger teeth, display a shallow groove on the ex-

ternal face to near the tip, which is probably owing to pressure, and a partial crushing. The points of the larger teeth are rather abruptly acute, and turned abruptly backwards. A portion of their increased length (·25) is to be attributed to the splitting off of the external dentary margin, and the exposure of the roots. No alveoli are shown, and the dentition is probably pleurodont, with anchylosis of expanded base as in true Labyrinthodonts.

MOLGOPHIS Cope.

This genus is established on remains represented by three specimens, which are two series of dorsal vertebræ with ribs, and a series of caudals. One of the dorsal series embraces sixteen vertebræ, the other fourteen; the caudal series, twenty-two.

From its serpentine form this genus may be compared with the Dolichosoma of Huxley, though a close relation does not exist between them. In the Irish genus the series of caudal vertebræ is quite short, and the ribs are short and but little curved. In Molgophis the tail has been like that of an elongate serpent, and the ribs are as well developed as those of many reptiles.

Though no limbs or arches can be certainly found, a rather quadrate, parallelogrammic piece, about as long as the diameter of a vertebra, may be a femur. This is, however, very doubtful.

The characters of the genus are, a long serpentine body, without dermal armature, so far as discoverable; the vertebræ large and broad, with very prominent zygapophyses and moderate neural spine, those of the caudals without narrowed bases (and grooved or serrate edges, most probably). ? Limbs and cranium unknown.

This genus differs from Urocordylus in its caudal vertebræ, and from Ophiderpeton in its dorsals; the latter, in their zygapophyses projecting laterally, resemble those of Amphiuma. It differs from Sauropleura in the absence of ventral dermal bands and in the longer body, without indication of limbs. The size of the vertebræ would indicate a body of the size of a rattlesnake, (C. h o r r i d a), and therefore too large for the species named Brachydectes n e w b e r r y i.

The ribs are long, and though the head is not bifurcate, there appear to be both tubercle and head on the dilated extremity. They show themselves, where crushed, to have had a large median vacuity.

Molgophis macrurus Cope.

The neural arches, viewed from above, have a posterior V-shaped outline, from the fact that the broad zygapophyses meet on the median line, and spread out distally over the broad anterior ones adjoining. The latter appear to be somewhat concave, and to border the former exteriorly as well as inferiorly. The base of the neural spine extends to the posterior emargination, but not quite to the anterior. The breadth of the dorsal vertebra above is equal from the emargination behind to the anterior margin of the anterior zygapophyses.

The caudal series must have been very long, as there is very little diminution in the size of the vertebræ throughout the series preserved. They present much the same form as the dorsals, but are more contracted medially, and the zygapophyses have a more transverse direction. There may indeed be a diapophysial element beneath these, but the two cannot be distinguished if so. They are connected by longitudinal impressions indicating the existence of the tendinous bands in the longitudinal muscles seen in Amphiuma, or the osseous spicules in the same situation in birds. The neural spines, indicated by their narrow bases, occupied the lengths of the neural arch, and remind one of Amphiuma.

The ribs are long for a Batrachian, but shorter than in a reptile. They are well curved, chiefly near the proximal extremity. The longest I can find, measured by a chord, equals two vertebræ and two-fifths. Three vertebræ

measured along the median line above equal eleven lines; one of these is 3·6 lines in width above; width of a (?) posterior caudal 3 l.

This animal has been, like Amphiuma, a snake-like Batrachian, but probably of even more elongate form. How near its affinities to this genus may be, cannot be ascertained, owing to want of important parts of the skeleton, but it differs in the important feature of the large, well developed ribs.

LABYRINTHODONTIA.

DITCYOCEPHALUS Leidy.

Dictyocephalus elegans Leidy, Proc. Acad. Nat. Sci., 1856, 256. Emmons Geology North Amer., p. 59. Tab. 31.

Triassic Coal Measures, Chatham Co., N. Carolina.

CENTEMODON Lea.

Centemodon sulcatus Lea, Proc. Acad. Nat. Sci., Phila., 1856, 78.

Triassic Shales near Phœnixville, Chester Co., Penn.

BAPHETES Owen.

Baphetes planiceps Owen, Quart. Journ. Geol. Soc. Lond. x, 1853, (xi, notes).

Carboniferous Coal Measures of the Joggins, Nova Scotia.

EUPELOR Cope.

Gen. nov. *Char.* Teeth subcylindric, with large pulp cavity at the basis only; external surface without grooves; dentine divided by numerous flat vertical laminæ of a dense substance, probably enamel, which radiate from very near the pulp cavity to the external enamel layer.

The species on which this genus depends was originally described by the writer as a Mastodonsaurus. The latter genus, however, exhibits external grooves where the inflections of enamel enter and separate the dentine. These inflections, as is well known from the figures and descriptions of Professor Owen, are more or less convoluted, some of them very highly so. The laminæ of the teeth of the Eupelor cannot be looked upon as inflections of enamel, but rather as branches. They are exceedingly thin, and our sections do not demonstrate them to be double. If they are double they are very much more attenuated than the external enamel stratum. They may be distinguished in a section of the wall of the pulp cavity at the base of the root as well as elsewhere.

Eupelor durus Cope, *Mastodonsaurus durus* Cope. Proceed. Acad. Nat. Sci., Phila., 1866, 249.

From the Triassic Red Sand Stone near Phœnixville, Chester Co., Penn.

On AGAPHELUS, a genus of toothless Cetacea.

BY EDW. D. COPE.

During the autumn of 1866 a whale was cast ashore on the Long Beach, Ocean Co., N. J., opposite Westecunk, on the other side of Little Egg Harbor, near the residence of Wm. A. Crane. A recent visit to the spot furnished me with the means of determining the species to which this monster of the deep belonged, although not with the completeness desirable, as the tide had a short time previously taken off the most bulky part of the carcass. Thus the cranium, cervical and dorsal vertebræ, with the first ribs, the most important portions for its identification, were lost. There were preserved, however, the mandibular arch, ear-bone, one scapula and both fins, numerous ribs, many

lumbar and caudal vertebræ, with the baleen from one side of the maxilla. These portions, with a few prominent points dependent on the observations of Wm. A. Crane, serve to indicate a species not only new to our fauna, but new to modern science. The evidence of my informant, as that of an old and experienced coaster and waterman, and one familiar with the appearance of our cetaceans, confirmed by his sons and by the specimens preserved, so far as they went, I consider reliable. That the species should have remained undescribed until the present time will not appear surprising to those who read carefully Gray's recently issued "Catalogue of Cetaceans," or Eschricht and Reinhardt "Om Nordhvalen," Copenhagen, 1861.

The scapula preserved is low and elongate, with well-developed acromion and coracoid process. It is evidently of the type of Balænoptera and Physalus; the ulna and radius relatively less elongate than in Sibbaldius laticeps and borealis, being 1·5 as long as the humerus, thus resembling Physalus. The four fingers, with the second much the longest, form a fin of the type of these genera. The ear-bone is much more compressed than in Physalus antiquorum or Sibbaldius laticeps. The mandibular ramus is rather massive, moderately curved, and with a more elevated coronoid process than in any whale that I have seen. The greatest peculiarity is in the form of the lumbar and anterior caudal vertebræ; they are of a much more elongate form than any I have seen or found figured, excepting those of the Balænoptera rostrata (as figured by Gaimard in Voyage de la Recherche), which, however, are relatively shorter. Those of the present species are of greater length than transverse diameter, the lumbars most elongate; all furnished with an acute hypapophysial keel and concave sides, and entirely transverse diapophyses. This peculiarity is consistent with the account of my informant, who stated the animal to have been of an unusually elongate and slender form. When it came ashore it had perhaps been dead ten days; the flukes and muscular region as far as the third caudal vertebra had been devoured, probably by sharks and killers, and the abdominal region much lacerated; the edge of a fin preserved was slit by the teeth of some carnivorous enemy. The measurement from the end of the muzzle to the end of the third caudal was 35 feet, which may be reduced to 33 feet axial. Up to this point the dorsal line was, according to my informant, entirely smooth, without knob or fin, or scar of one; hence I suppose the fin (if present) to have been situated as in Sibbaldius, &c., at the posterior fourth of the length, and not as in Balænoptera, on the posterior third. It may then be safely assumed, bearing in mind the form of the vertebræ, that ten feet of the whale's length had been removed, making in all 43 feet. That the species attains over 50 feet is probable, as the present individual was quite young, the epiphyses separating from the vertebræ with the greatest ease. The slender form of the animal is corroborated by the slenderness and slight curvature of the ribs, one attached beneath the scapula, probably the second, being narrower than the corresponding ones in Sibbaldius. I therefore think it most probable that in this form the anterior ribs are single-headed.

The baleen is peculiar; throughout the length of the maxillary bone it nowhere exceeded one foot in length, and the width of the band, or length of the base of each plate, four inches. It is of a creamy-white; the fringe very coarse, white, and resembling hogs' bristles.

The proportions in most respects present a contrast to those of Physalus species, and Sibbaldius species. While the cranium and fin of the Physalus antiquorum are of about equal length, the latter is four-sevenths the former in the present species. In the Physalus the cranium enters the length 4·7 times; in Sibbaldius laticeps 4 06, and in the present species 6·6 times; in Balænoptera rostrata 4·5 times.

In general features this Cetacean seems to be an intermediate form of the toothless whales; and an additional feature, which depends on the observation of my friend W. Crane, and in which I cannot conceive it possible that he should be mistaken, indicates still more conclusively that it pertains to a genus

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not before characterized. The whale was first driven on shore on its back, and the gular and thoracic regions were seen to be entirely without ridges or plicæ of any kind, but as smooth as any other part of the body, or as the throat of a right whale, Balæna c i s a r c t i c a Cope, which is not uncommon on the same coast.

This my informant told me was the species known among the whalers as the "Scrag Whale." Though this name is indefinite when applied by whalers of different nationalities, it is probably used with accuracy by those accustomed to any particular region. At any rate I have little doubt that this is the species called by the same name by Dudley, who in 1725 wrote an account of the whales known by the whalers of the coasts of New England. He says it is near the right whale (B. c i s a r c t i c a) in figure also; "is near akin to the fin-back, but instead of a fin upon its back, the ridge of the after part of its back is scragged with half a dozen knobs or knuckles. He is nearest the right whale in figure and quantity of oil. His bone is white, but won't split." This is published, with an account of the other species known, in the 33d volume of the Philosophical Transactions. He mentions particularly the fin-back and hump-back whales, describing the deep folds of the chin, throat and sides of those genera. There can be little doubt that his "scrag whale" had a smooth throat like the Balænæ, and not a plaited one like the Balænopteras and their allies. By the preceding account it has been shown that the species has but four slender fingers at the carpus; hence it is obviously the type of genus intermediate between Balæna and Megaptera, not hitherto recognized,—furnished, however, with the scapula of Balænoptera.

Captain Atwood, a resident of a part of the peninsula of Cape Cod, Mass., who is a good observer of the life of the ocean, thus writes of the scrag whale in J. A. Allen's Catalogue of the Mammals of Massachusetts, in the Proc. Boston N. H. Soc. for 1868:

"Scragg.—A species of whale known by this name, and nearly allied, if not identical with the right whale, is sometimes taken here. It is the opinion of many of our whalemen that they are not a distinct species, but are the young right whale that lost its mother while very young, and has grown up without parental care, which has caused a slight modification. The most prominent feature is on its dorsal ridge; near the tail there are a number of small projections or bunches, having some resemblance to the teeth of a saw. It has no dorsal fin or hump on its back."

Additional evidence of the existence of this genus has been furnished by the Smithsonian Institution. In accordance with recommendations and directions furnished by the writer, Wm. H. Dall, the enterprising director of the West Coast Scientific Exploring Expedition, originally commanded by Dr. Kennicott, sent to the Institution drawings and descriptive notes of the grey whale of the coasts of Upper and Lower California. The writer has also examined an almost complete set of whalebone, with some other portions of the same species, in the museum of the Essex Institute, at Salem, Mass. The baleen is similar in character to that of the present species, but presents specific differences. The notes of Capt. Dall indicate a long-finned, smooth-throated whale, with a flat-pointed head like a fin-back, and no dorsal fin, but a series of knobs on the posterior region of the back. That it in all respects conforms to the generic type of the Atlantic species, can be determined from the description which follows.

The Atlantic species was named from Dudley's description by the compiler, Erxleben, without his adding to our knowledge of it, Balæna g i b b o s a. I will follow Dr. Gray in adopting this name. The latter author, in his excellent Catalogue of Seals and Whales in Brit. Mus., refers it, on the basis of the same description, to Balæna, with doubt.

Genus AGAPHELUS Cope.

Fingers four, elongate. Cervical vertebræ? Lumbar and anterior caudal

vertebræ longer than their greatest diameter. Dorsal fin wanting. Gular and pectoral region without folds. Scapula with well developed acromion and coracoid. Baleen narrow, short.

AGAPHELUS GIBBOSUS Cope.

Scrag Whale, Dudley, Philos. Trans. xxxiii., 250, and of The Whalers.
Balæna gibbosa Erxleben, Systema Mammalium 610 (from Dudley), and after him of Gmelin, Bonnatere, Lacepéde, Virey, Gerard, Desmarest & Fischer. Gray, Catal. Brit. Mus. 1850, p. 18, and 1866, p. 90.
Agaphelus gibbosus Cope, Proc. Ac. N. Sci. Phila., 1868, 159.
Balænoptera rostrata Cope, Proc. Ac. Nat. Sci., Phila., 1867, 147.

	Ft.	In.
Total length (estimated) of young	43	
Length to third caudal vertebra	33	
Length of cranium (estimated)	6	10
" mandibular ramus (in curve)	6	
" pectoral limb	4	
Width of " "		15
Length of humerus		11·5
" radius and ulna		17
Posterior margin of scapula		14
Length of coracoid from glenoid cavity		3·3
" glenoid cavity		6·3
Mandible, length from condyle to coronoid		13·5
" depth at coronoid		8·5
" " 2·5 feet from coronoid		4·6

The form of the mandibular ramus is peculiar, and more like that of the Balænoptera rostrata than any other. It is triangular in section, having an inferior angulated ridge, and a broad, slightly convex, superior face, instead of their usual ridge. Such a ridge leaves the coronoid process, but soon turns inwards to form the inner outline. Width of the superior face 3·5 inches. The coronoid process is quite elevated, and turned outwards. In the fresh animal the lower lip included the upper all round. The laminæ of whalebone are placed on a base having a sigmoid flexure. Greatest depth of the gum 1 in. 3 lines. Within each principal lamina are two supplementary laminæ, the intermediate being the narrower, the inner triangular, its intermediate bristles arising from the gum. The bristles of the supplementary plates are longer and finer than those of the outer; in the latter, three series of bristles are enclosed between very thin enamel plates. All the laminæ are thin, five in an inch, and split transversely straight; white cream-colored, with a purplish shade near the centre of the base. The ulna is slender, but furnished with a prominent rounded and flattened olecranon, which is prolonged into a thin cartilaginous plate, formed like the diapophysis of a vertebra, and in the plane of the ulna; this structure appears to have been ossified in the Sibbaldius borealis Fisch., as figured by Dubar In the Agaphelus gibbosus it occasions an abrupt angulation near the basal third of the inner margin of the fin. In the scapula, the coracoid is in its plane, but the larger acromion diverges outwards.

The anterior caudal vertebræ are more elongate than the lumbosacral, less depressed, and with the centra in every way larger. All are sharply keeled on the median line below, with a concave face between the keel and the base of the diapophysis. The caudal and lumbosacral diapophyses are obspatulate, the anterior becoming narrower. The neural spines of the lumbar vertebræ are much elevated, concave above both before and behind, the zygapophysis measuring a point considerably below the middle.

	In.
Third (?) caudal (not perforate) length centrum	7·3
depth	6
width	6·5

	height neural spine	9·5
	zygapophysis	4·3
	length diapophysis (from front base)	3 3
Lumbosacral 1 ;	length centrum	7·3
	depth	5·3
	width	6·3
	height neural canal	2·5
	width	1·5
	height neural spine	15·3
	zygapophyses	5·5
	length diapophysis	7·5
	greatest width do.	5·3
Lumbosacral 2	(more anterior) length centrum	6·3
Lumbosacral 3	(anterior) height centrum	4·3
	width "	6
	length diapophysis	7·7

The ear bone is much compressed, with an inferior carina, towards which the lip of dense bone is suddenly decurved. The longitudinal opening is much contracted, especially anteriorly, where the bone is pinched up into a keel, and there is no abrupt concavity of the inner lip at that point. External surface not very rugose. Total length 3 in. 2·5 lines.

The owner of the whale tried out about one-fourth of the blubber, and procured sixty-five gallons of oil, which would give about four hundred gallons for the whole; the thickness of the adipose layer would not average 4 inches, the greatest thickness was 5 inches.

This species was black above and white below, the sides lead-colored, with longitudinal shades of the darker color; fins, basal half white, terminal black.

AGAPHELUS GLAUCUS Cope, sp. nov.

The points in which this species differs from those of the genus Balæna, previously known, are numerous, and will no doubt be increased on a further knowledge of the animal. The head, between one-fourth and one-fifth of the total length, allies it to the shorter headed species. From the B. australis, the number of dorsal vertebræ, and the color and shortness of the baleen, distinguish it, and no doubt other features will be brought out when we are acquainted with the Cape species. The dorsal serration is not known to occur in any species of the genus Balæna, though said to be characteristic of the A. gibbosus, whose characters I have just given. Two Balænæ have been described as inhabiting the north Pacific Ocean, Balæna sieboldii Gray,* and Balæna cullamach Chamisso.† Both have been established on figures carved by the natives of the Japanese and Alentian Islands respectively, the former under the supervision of a naturalist, the traveller Siebold. The carving of the B. cullamach, judging from the figure given by Chamisso, can but doubtfully represent any species, but which, if it exist, will rest on the following diagnosis of its describer: "Rictu amplo forma litteræ Scurvato, elasmiis maximis atrocorruleis, spiraculis flexuosis in medio capite, tuberculo in apice rostri (ex imagine) pectore pinnisque pectoralibus albis dorso gibboso sexpinnato."

These are, however, true Balænæ. A species of Agaphelus exists in the Kamtschatkan Seas, according to Pallas, who, however, derives his information solely from wooden models made by Aleutian Islanders. This is not sufficient basis for an introduction to the scientific system, yet Pallas indulges in applying to it the name *Balæna agamachschik*. The pectoral limb of this species is said, however, to be white, with the under side of the flukes, charac-

* Catalogue Cetaceans, 1865, 96, Fauna Japonica, Temminck & Schlegel, t. 28, 29.
† Nova Acta Acad. Caes. xii., p. 251, Tab.

ters not found in the A. g l a u c u s Dr. Gray has already (Catal. Brit. Mus.) indicated that this, if reliable, indicates a genus unknown to him.

The Agaphelus g l a u c u s is the gray whale of the coasts of California. Two specimens have been examined by my friend, Wm. H. Dall, of the Scientific staff of the U. S. Russian American Telegraph Expedition, one of them near Monterey, and descriptions as complete as the state of the specimens would allow, were made. These, which were sent to the Smithsonian Institution, and placed in my hands by Prof. Baird, are quite sufficient to indicate a whale of a species hitherto unnoticed, and to render certain its future identification.

Specimen No. 1, a skeleton nearly complete.

	Ft.
Length of cranium	10
Of dorsal vertebræ	12
Lumbar and caudal (except of the fluke)	26
? Vertebræ of fluke	? 3
Total	51

Dorsal vertebræ and ribs, thirteen ; lumbar and caudal (those in the fluke cut off with it), 28. Scapula, breadth and height not very different, with a short, broad coracoid process; its head opposite first rib. Apparently only four fingers, of which the second is the longest. 145 laminæ of baleen on each side, the longest eighteen inches long; color light yellow.

Specimen No. 2, killed by the " killers," (orca) ; skeleton still concealed by mass of muscle, etc.

External measurements.

	Ft.
Flukes to anus	14½
Anus to sulcus penis	2
Length of sulcus	1½
Latter to plane of flippers	15
Plane of flippers to end of mandible	15
Total	48

The lower jaw is four inches longer than the upper ; the blow-holes are entirely concealed by four dermal plicæ, which accounts for the small misty spout peculiar to the species.

	Ft.	In,
Length of flipper and shoulder	6	
" mouth	10	
" exterior canthus of mouth	1	6
" from chin to eye	10	4
" from eye to margin of canthus		6
Width of caudal flukes	8	9
Width of mouth at canthus	4	
From chin to blow-holes	4	9
Longest baleen		14

Head of humerus opposite third rib ; anterior angle of scapula just anterior to first rib. On the vertebral line, for fourteen feet from the caudal flukes, is a series of 18 ridges, like the teeth of a saw, which are altogether dermal in their character. Blubber 4—8 inches thick, thickest near the jaws and on the back near the tail ; yield of oil 35 bbls. Epidermis 1 inch thick, carium ·75, with numerous pores. Blow-holes 2—4 inches apart. On each side of sulcus penis a mammary sulcus a few inches shorter.

Color above and below, black, with a gray bloom like a plum. This distinguishes this species from the known Balænæ of the Pacific, which are more or less white on the belly and fin.

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Specimen No. 3. A full set of baleen of one side the maxillary is in the Mus. Essex Institute, Salem, Mass. A portion of this, kindly lent me, exhibits the following characters: Compared with that of the A. g i b b o s u s, it is longer and has narrower basis. The plates moderately and simply concave, while those of the latter are sigmoidal, most curved near the outer margin, in cross section. The bristles of the California species are very coarse, varying from one to three series between the enamel plates. The bristles of the A. g i b b o s u s much finer, three series together. Length of the latter 8·5 inches, width at base 4·4 inches. In the Agaphelus g l a u c u s Cope, 22 in. in length, width at base 6 in. In the former nearly 6 in an inch, in the latter 2½. The baleen of the A. g i b b o s u s belonged to the specimen above described.

Two rough outlines accompany Capt. Dall s notes. Both represent the pectoral fin as rather elongate, not pointed, but rather broad at the extremity. A third sketch represents the inferior view, and in it we see two lines for grooves, one on each side the median gular line. This feature, if existing, is interesting, as indicating a tendency to the plicæ of the fin back whales.

This species has usually one calf at a birth, but one was recently taken at San Diego with two fœtuses. Penis 27 in. long, smooth, coarsely papillose, slightly bifid at tip, where the urethra is about the size of a goose quill. (Dall's m. s.)

Oct. 6*th.*

The President, Dr. Hays, in the Chair.

Thirty-five members present.

The following paper was presented for publication:

Notice of some American Leeches. By Joseph Leidy, M. D.

Oct. 13*th.*

Mr. Cassin, Vice-President, in the Chair.

Thirty-four members present.

The following papers were presented for publication:

Notice of some Remains of Extinct Vertebrata. By Joseph Leidy, M. D.

On the Origin of Genera. By Edward D. Cope.

On some Cretaceous Reptilia. By Edward D. Cope.

On variations in Taxodium. By Thomas Meehan.

Oct. 20*th.*

The President, Dr. Hays, in the Chair.

Thirty-six members present.

Dr. F. A. Genth made some observations on the occurrence of cupriferous ores in Texas.

Dr. A. R. Roessler, Geologist at the U. S. General Land Office at Washington, had sent him for examination a specimen from Weatherford, Archer Co., Texas. It was a piece of copperglance, containing 55·44 per cent. of copper, pseudomorphous after wood or a vegetable substance. It resembled so much similar pseudomorphs found in the Permian formation at Frankenberg in Hesse, and

elsewhere in Europe, that he pointed out the probability of its occurring also in the Permian formation, and requested Dr. Roessler to obtain fuller details with reference to its occurrence. A few days ago Dr. Roessler received an answer to his inquiries from the General Land Office agent in Texas, with more specimens, and the following report, which he sent to me:

"After traversing the cretaceous and carboniferous series northward of Weatherford, Archer Co., Texas, I was agreeably surprised by a grand panorama of the Permian formation. This system is extensively developed in Russia between the Oural Mountains and the River Volga, in the north of England, and in Germany, where it is mined for its treasures of copper, silver, nickel and cobalt ores. It has not heretofore been known to exist in this State, or it had been mistaken for the Triassic system, which is overlying the former to the south-east. Its hills, which have been traced throughout Archer and Wichita Counties, resemble in shape the copper-bearing or gossan-crested upheavals in Ducktown, Tenn., but they are of a different age and composition. They are nearly barren, and, towering above the most beautiful mesquit prairies fringed by the finely-timbered bottoms of the tributaries of Red River, are exceedingly picturesque. The members of the Wichita System, as far as open to ocular inspection by out-crops or cross-cuts, making allowance for climatic differences, correspond closely with the lower strata, discovered at Perm and Mansfeld, but its mineral resources are evidently more promising. Such numerous veins of copper ore have been traced over the summits and sides of the hills, that hardly a hundred and sixty acre tract could be found without ore on the surface. The ore crops out, as, for instance, on the Isbell Douglass Ball, in such quantity and quality that the mere collection of it, without mining, would prove remunerative. It is supposed that those veins are cotemporaneous with injections at different ages of quartz, trap and porphyry. The vein lodes are parallel with the strata, but there is sufficient evidence that they partake of the nature of true veins. Cupriferous and ferruginous cross-courses, feeders and leads of manganese are often met with. A cross-cut was made to a depth of about fifteen feet upon the Isbell lode, and ten hours work resulted in the raising of 6000 pounds of copper ore. This ore is far superior to the ferro-sulphuret of copper, or copper pyrites, which ore is most generally worked in England, and it is, in fact, more profitable than the native copper as found at Lake Superior. It is easily smelted, and the strata in which it is found can also be more economically excavated than any other in which copper ores occur."

Dr. Le Conte, in continuation, spoke of the occurrence of calamite tinged with copper in the Permian formation of Southern Mexico.

Mr. Gabb mentioned the deposits of grey copper near the Colorado River, in Arizona, scattered over the surface, the debris of metallic veins.

Dr. Leidy remarked, that shad had been brought to our markets, for several years past, during the late autumnal months, which were caught in salt water, perhaps in Delaware Bay or off the Jersey coast. When the shad ascend the river to spawn, their stomachs and intestines appear to contain so little that the question is often asked as to the nature of their food. A shad which Dr. L. had purchased a few days since, on examination, was found to have the stomach full of small fishes. There were 30 of them, from 2 to 4 inches long, and all one species, which appears to be the Sand-launce, *Ammodytes Americanus.*

Oct. 27th.

MR. VAUX, Vice-President, in the Chair.

Twenty-six members present.

Philip S. Wales, M. D., was elected a member.

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THE CETACEA.

By E. D. COPE.

From the AMERICAN NATURALIST, July, 1890.

THE CETACEA.

BY E. D. COPE.

THE Cetacea, as the inhabitants of the water areas of the earth's surface, have had ample space for variation and multiplication of forms, an opportunity of which only a moderate advantage has been taken. The conditions have been more uniform than those to which land mammals have been subject, and a corresponding uniformity prevails in this order. Owing to their habitat, opportunities for their preservation have been better than in the case of animals of the land, and accordingly great deposits of their bones exist, notably on the east coast of the United States, and in certain deposits of Belgium and Italy. Among the species brought to light in these localities, as among those now existing, we find examples of the most gigantic, not only of the Mammalia, but of the Vertebrata. The exising *Balænoptera borealis* reaches a length of over one hundred feet; and several other species, including the sperm whale, attain to eighty feet.

The order of Cetacea is one of those of whose origin we have no definite knowledge. It appears sparingly in the Zeuglodontidæ in the Eocene period, and has its greatest multiplication in the ages of the Miocene. The Zeuglodontidæ are the most generalized family, and forms intermediate between them and the modern Cetacea are found in Miocene beds. Modern types are, however, contemporaries of the latter, and these have achieved a multiplication of forms in Pliocene and modern times.

The line of successional modification of the Cetacea is found in changes in (1) the shape of the skull; (2) the extinction of the dentition; (3) the shortening of the cervical vertebræ; and (4) in the separation of the ribs from articulation with the vertebral centra. The modification of the shape of the skull is related to the gradual transfer of the external nostrils to more and more posterior positions, until they remain, in the extreme types, above, or even behind above, the eyes. In this process the nasal, frontal and parietal bones become excessively abbreviated, so that in the modern toothed whales, they form a narrow band between the nostrils and the superior border of the occipital bone.

The order is naturally divided into three sub-orders, which are defined as follows:

External nostrils on the superior side of the muzzle; teeth present; ribs with two heads; *Archæoceti.*

External nostrils above gullet; teeth generally present; no whalebone; some of the ribs with two heads; *Odontoceti.*

External nostrils above gullet; teeth wanting; the gums supporting "whalebone"; ribs articulating by tubercle only; *Mysticeti.*

All of the above characters are those of divergence from the principal mammalian stem, and have relation to the conditions of aquatic life. Thus the posterior position of the nostrils permits inspiration without the elevation of the muzzle above the water-level, which is rendered difficult, if not impossible in the most specialized types, by reason of the extreme flatness and inflexibility of the cervical vertebræ. The absence of teeth is appropriate to the habits of the types which lack them. Thus the Physeteridæ among Odontoceti feed principally on squids, whose soft bodies are swallowed whole. The Mysticeti feed on minute Crustacea and Mollusca, which they retain in the mouth by straining the water through their bristly whalebone, or baleen. The disarticulation and disappearance of the heads of the ribs in the Mysticeti, is appropriate to the support which all the viscera derive from the fluid medium in which these large animals live. Strong articulation of the head of the ribs to the vertebral column is no longer necessary.

Paleontology confirms the inference derivable from their anatomy, that the phylogeny of the Cetacea has followed the order, Archæoceti, Odontoceti, Mysticeti.

The mechanical causes which may have given origin to the modifications which measure this succession, may be suggested as follows: The shortening and obliteration of the neck is probably due to disuse, since the general mobility of the body in a watery medium renders much flexibility of the neck unnecessary, the entire body being readily turned about. It may have resulted, also, from the increase in the relative proportions of the head, which renders it extremely difficult to handle; a function which is, in the modern Cetacea, quite aborted. The early and rapid reduction, and in some lines, extinction of the dentition, is a result of disuse consequent on the increasing percentage of soft or minute food used by the more modern types. So the loss of the rib-heads in the Mysticeti may be traced to disuse, since, as above remarked, they lack the strain caused by the weight of the thoracic and abdominal walls and the contained viscera, which they experience in animals which are not supported by some external medium. The same reduction took place in the ocean-dwelling Plesiosauria,[1] and in those terrestrial reptiles in which the weight of the body is borne on the earth, as the lizards proper, and snakes. As regards the gradual transfer posteriorly of the external nostrils, the following mechanical hypothesis has been suggested. They have been used as a discharge pipe for air and water from the lungs and mouth, and, of course, facility of exit is directly as the shortness of the conduit. It is possible that the constantly recurrent presence of a column of air and water on the posterior inferior wall of the nareal canal has literally pressed back this obstructive roof, until it has ceased to resist the outflow by becoming vertical.

I. ARCHÆOCETI.

This suborder embraces but one known family, which is defined as follows:

Frontal bones with flat, expanded supraorbital region; teeth two-rooted posteriorly, one-rooted anteriorly; *Zeuglodontidæ.*

[1] It must be remarked here that the equally marine Ichthyopterygia have two-headed ribs, but they are of equal length, close together, and mechanically equivalent to one.

The species of this family belong to the genus Zeuglodon[2] Owen, although when the *Z. brachyspondylus* Müll. is better known it may be found to be referable to a distinct genus, Doryodon Gibbes. The longer known *Z. cetoides* Ow. is distinguished by many peculiarities. Its skull presents a long symphysis of both premaxillary and mandibular bones. The cervical and dorsal vertebræ are of similar and medium length, while those of the lumbar region are remarkably elongate. The fore-limb was short, and in its cubital region quite narrow (teste Müller). The enamel of the teeth is wrinkled, and the posterior two-rooted teeth have coarsely serrate cutting edges fore and aft. The animal could not have been less than seventy feet in length. Bones of species of Zeuglodon have been found in the Upper Eocene of Arkansas and the Gulf States (in the White Limestone of Alabama), and of England and Egypt. It is also recorded as occurring in the Miocene of Malta.

II. ODONTOCETI.

This group is the most numerously represented by species, recent and extinct. The families differ as follows:

I. Teeth of two types, one and two-rooted.

Neck longer; teeth in both jaws; *Squalodontidæ.*

II. Teeth uniformly one-rooted,

a, Ribs nearly all two-headed.

Teeth in both jaws; neck generally longer; *Platanistidæ.*

Teeth in lower jaw only; neck short; *Physeteridæ.*

aa, Four or five anterior ribs only two-headed.

Teeth in both jaws; neck short; *Delphinidæ.*

The SQUALODONTIDÆ resemble the Zeuglodons in the form and character of their teeth, but the form of the skull is very different. They nevertheless, by their intermediate position, indicate the ancestral relation of the Zeuglodontidæ to the other Cetacea. But little is known of the skeleton of the Squalodontidæ. The species occur in Miocene beds of North America and Europe. They did not attain such huge proportions as the Zeuglodons, and did not exceed thirty feet at the most. The genera known are two, as follows:

[2] *Basilosaurus* Harl.

The posterior molars two-rooted; *Squalodon* Gratel.
Some of the posterior superior molars three-rooted; *Trirhizodon* Cope.

Squalodon grateloupii Pedroni and *S. antverpiensis* Van Ben. are the most abundant European species. In America the *S. atlanticus* Leidy has been found in New Jersey and Maryland, and the *S. holmesii* Leidy, a species with more delicate teeth than the last, has been discovered in South Carolina.

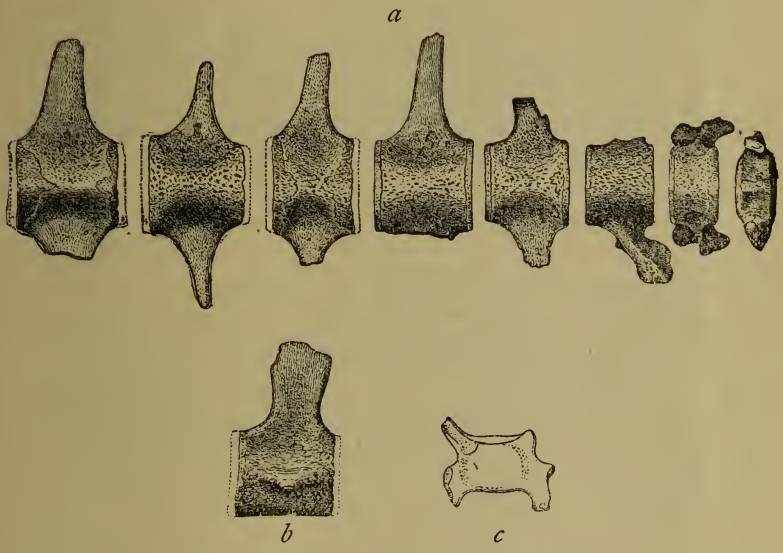


FIG. 1.—*Ixacanthus spinosus* Cope dorsal and lumbar vertebræ, two-sevenths natural size; *a*, from below; *b*, lumbar from side; *c*, cervical from front. Type; original; from Miocene of Maryland.

The greater number of the PLATANISTIDÆ are extinct. The genera differ much among themselves in the number and form of the teeth, and the relative form of the neck. Some of the species reach the size of the smaller whales, as the *Cetophis heteroclitus* Cope; but most of the species have the average dimensions of the dolphins. The genera differ as follows:

I. Teeth with roots extended transversely.
Teeth with lateral basal lobes; lumbar diapophyses wide; *Inia* Geoffr.

II. Teeth with cylindric roots.

α, Caudal vertebræ plano-convex.

No caudal diapophyses; *Cetophis* Cope.

αα, Caudal vertebræ plane.

β, Lumbar diapophyses spiniform.

Lumbar and caudal vertebræ slender; *Zarhachis* Cope.

Lumbar and caudal vertebræ short; *Ixacanthus* Cope.

ββ, Lumbar diapophyses wide, flat.

Muzzle elongate, slender; cervical vertebræ long; *Priscodelphinus* Leidy.

Muzzle slender; cervical vertebræ shorter; *Pontoporia* Gr.

III. Teeth with longitudinally flattened roots.

Teeth in entire length of maxillary bone; symphysis connate; *Stenodelphis* Gerv.

Teeth on all the jaws; symphysis not connate; an erect osseous crest on posterior part of maxillary; *Platanista* Cuv.

Teeth at the base of the maxillary only; muzzle produced into a sub-cylindrical beak; *Rhabdosteus* Cope.

IV. No teeth; an alveolar groove.

Muzzle depressed, elongate; *Agabelus* Cope.

The recent species belong to the genera Inia, Pontoporia and Platanista. The two first are found in the rivers of S. America, and the *Platanista gangetica* in the rivers of India. Their posterior ribs are one-headed. The genera with spiniform diapophyses of the posterior vertebræ are only known so far from N. America. The *Ixacanthus cœlospondylus* Cope was a short robust species about the size of a white whale. Another line of modification is seen in the attenuation of the vertebral column. The most remarkable elongation of the vertebræ is found in Zarhachis, a character which is only paralleled in Zeuglodon. Of the other genera, Stenodelphis, with its single species *S. canaliculatus* (Delphinus, von Meyer), has been so far found in the middle Miocene of Central Europe. Priscodelphinus occurs in the Miocene of North America and Europe. The *P. grandaevus* Leidy (Figs. 2 and 3), of the Miocene of New Jersey has a slender muzzle, with a full series of curved cylindric teeth; a neck like that of a seal

in proportions, and a long slender body. The first sternal segment is T-shaped, and the ribs are slender, compressed, and mostly two-headed. The paddles are unknown. Other species of the genus are found in the Miocene beds of Maryland. The species of the remaining five genera have been found thus far only in the Miocene of North America. Nineteen species of Platanistidæ have been described from the latter region.

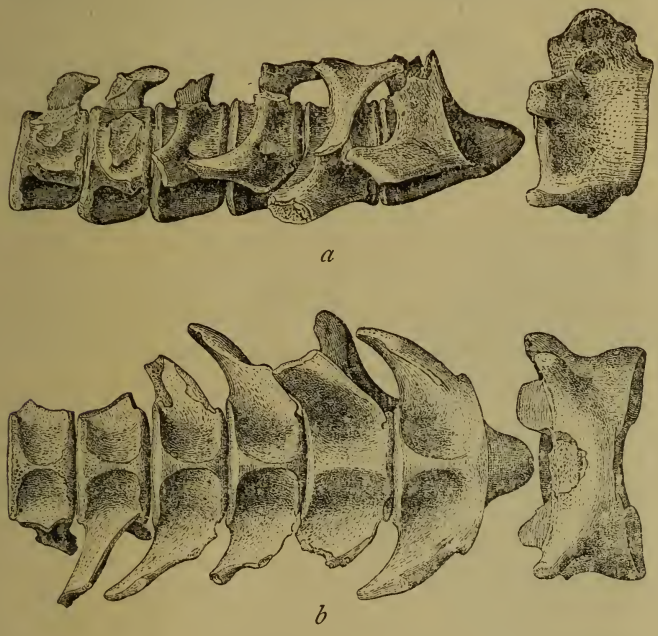


FIG. 2.—*Priscodelphinus grandaevus* Leidy, cervical vertebræ; *a*, from side; *b*, from below. Original; from Miocene of Cumberland County, N. J. One-third natural size.

One line of modification observable in the extinct genera is towards the extreme which is seen in Rhabdosteus Cope. Here the muzzle reaches an extraordinary elongation, and for the greater part of its length forms an edentulous cylinder, which resembles the beak of the sword-fishes. The few teeth which remain at the base of the muzzle are like those of Platanista, with roots compressed so as to be longitudinal, and crowns compressed so as to be transverse, to the axis of the skull. The *R. latiradix* Cope (Fig. 4.), is not uncommon in the Miocene beds of Maryland. Its

skeleton is unknown. The nearest approach to Rhabdosteus is made by the genus Stenodelphis. In Cetophis, the caudal centra have one face very convex, offering greater flexibility than is possible in any other genus. The *C. heteroclitus* is from the Maryland Miocene. A genus Lophocetus has been established for the *Delphinus calvertensis* of Harlan, also from the Maryland Miocene. Its position is uncertain; the skull resembles that of Inia, but the roots of the teeth are cylindric. The temporal and occipital ridges are very strong. Skeleton unknown. Delphinodon Leidy is represented by teeth only, from N. American localities, but a skull is described by Burmeister from Buenos Ayres, which shows that the nostrils are much more anterior in position than in Lophocetus.

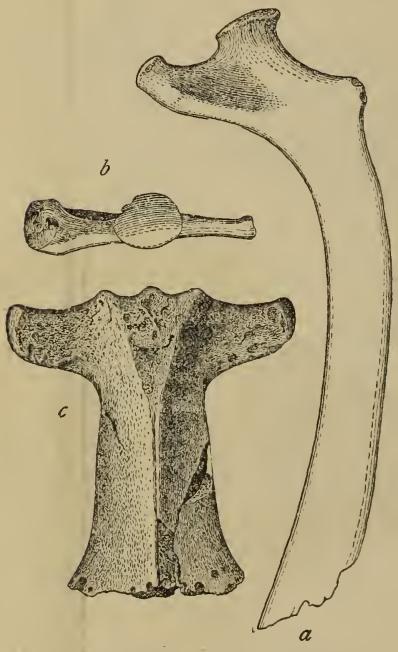


FIG. 3.—*Priscodelphinus grandaevus* Leidy; one-half natural size; Miocene of Cumberland County, N. J. *a*, rib from side; *b*, do. proximal extremity; *c*, mambrium sterni. Individual represented in Fig. 2.

Extinct and recent forms about equally divide the PHYSETERIDÆ, but the largest dimensions are reached by the recent sperm whale, *Physeter macrocephalus* L. The modifications of the family type are chiefly those of the dentition, but the skull develops crests of a peculiar character in a number of the genera. These are distinguished as follows:

I. Lower jaw with numerous teeth.

a, Teeth with crown and root continuous, and without enamel. Inion and temporal ridges forming a crest which encloses a basin-shaped cavity of the front. Zygoma complete; symphysis mandibuli long; *Physeter*[3] Linn.

[3] *Eucetus* DuBus.; *Physetodon* McCoy; *Stenodon* VanBen=*Orycterocetus* Leidy.

PLATE XX.

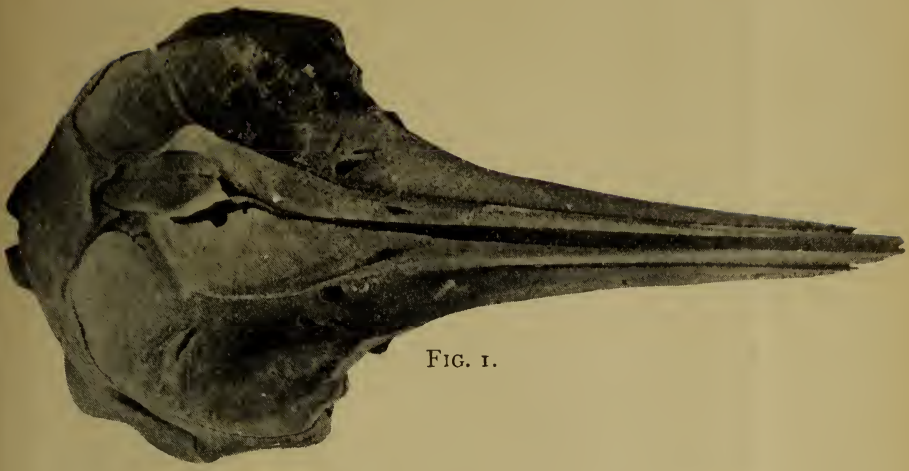


FIG. 1.

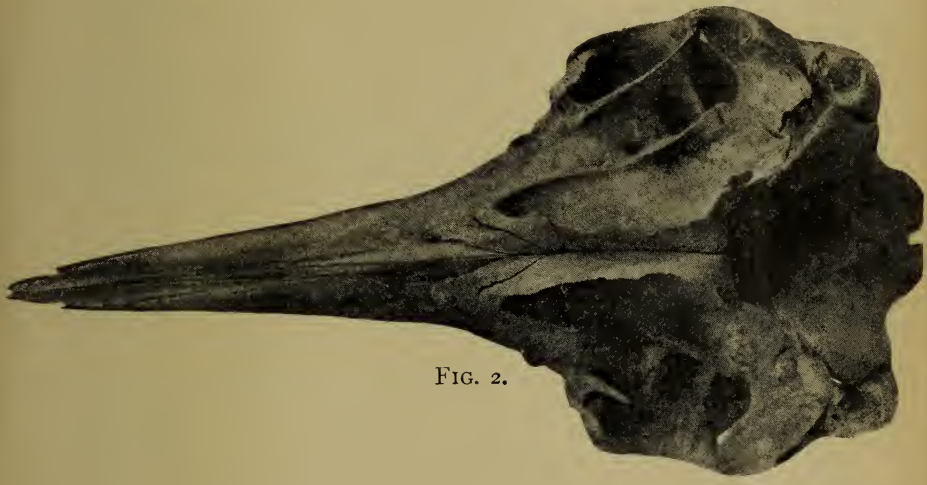


FIG. 2.

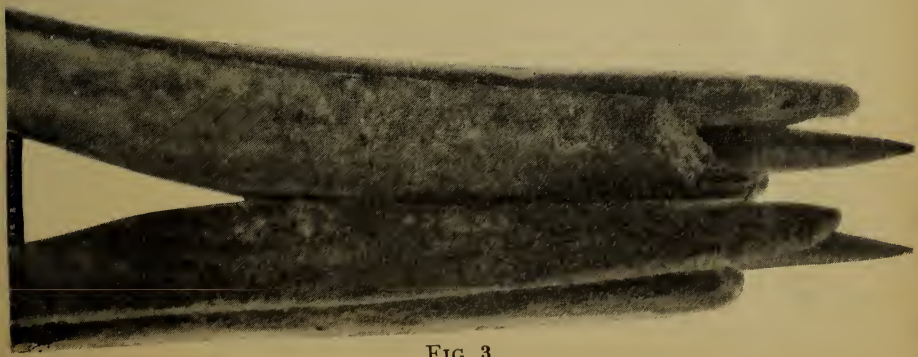


FIG. 3.

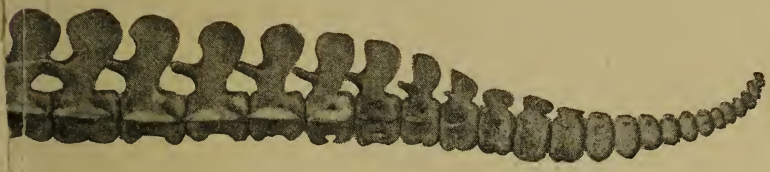
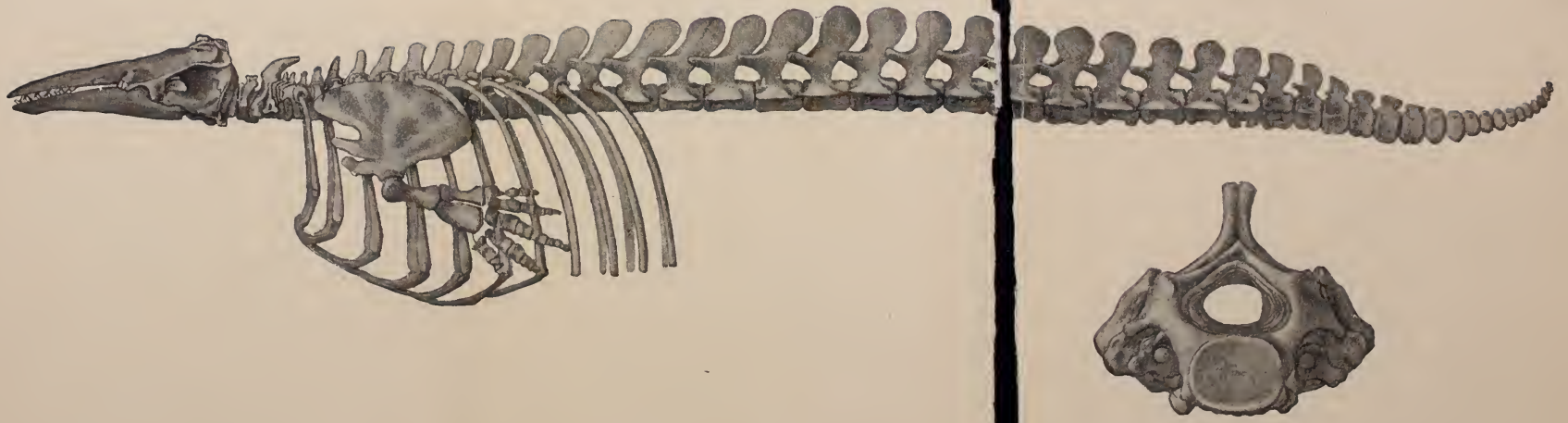


PLATE XXI.



Delphinapterus leucas Pallas.

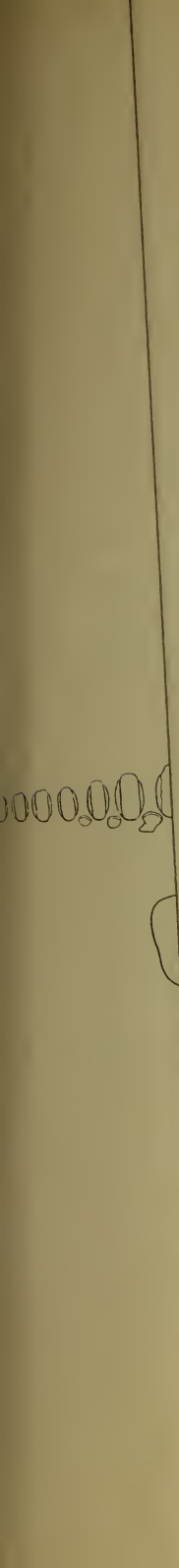
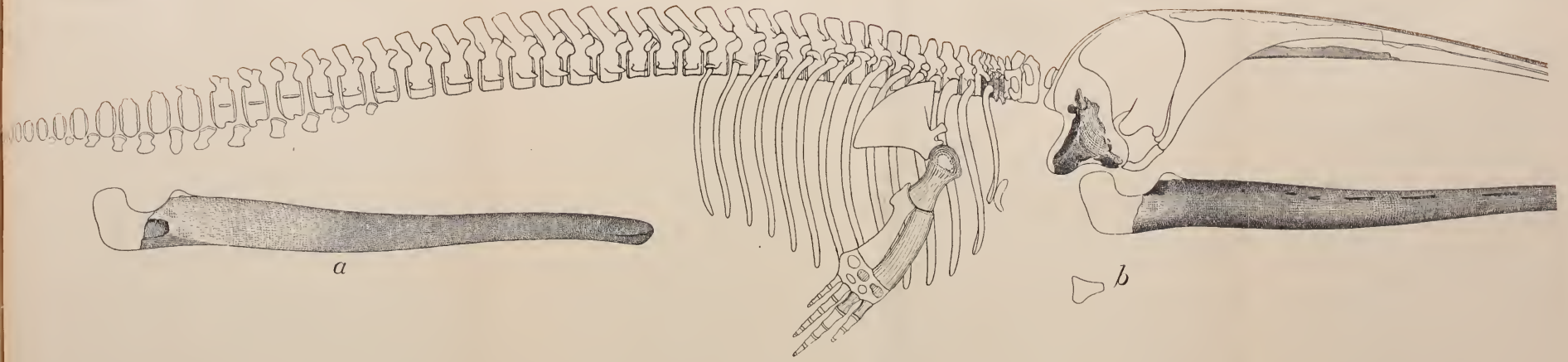


PLATE XXII.



Cetotherium cephalus Cope.

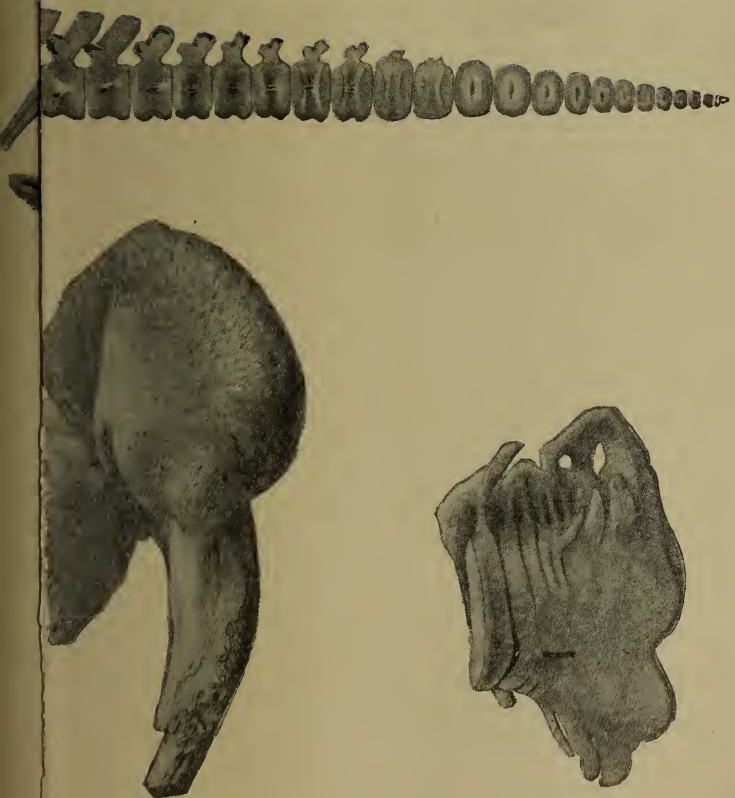
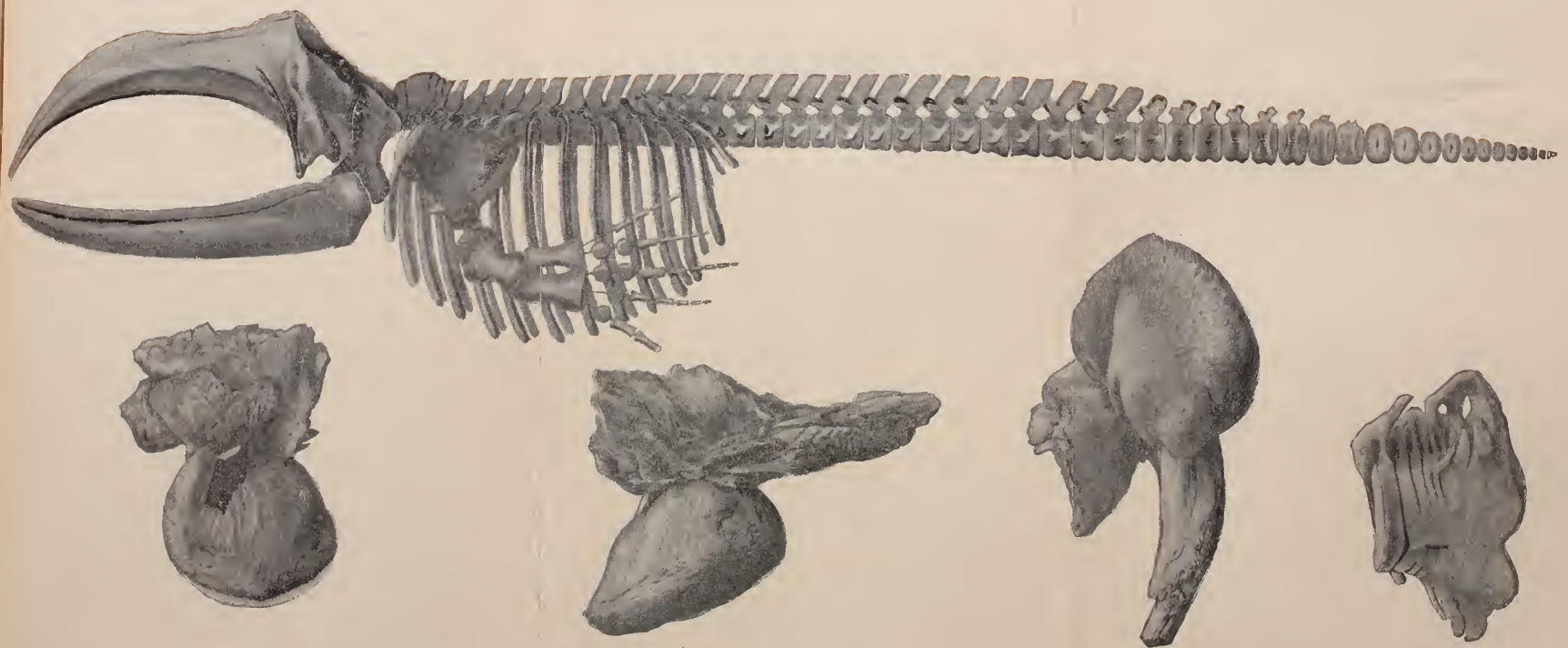


PLATE XXIII.



Balæna ci arctica Cope.

Zygoma interrupted; symphysis short; *Kogia*[4] Gray.

aa, Teeth fusiform, with enameled crown.

Cement coating thick; *Physodon*[5] Gerv.

aaa, Crown and root of teeth distinct; crown with enamel.

Cement very thick; *Hoplocetus* Gerv.

II. Low jaw with very few teeth.

a, Maxillary bones with vertical longitudinal crest behind.

A tooth at the extremity of each ramus mandibuli; *Anarnacus*[6] Lacep.

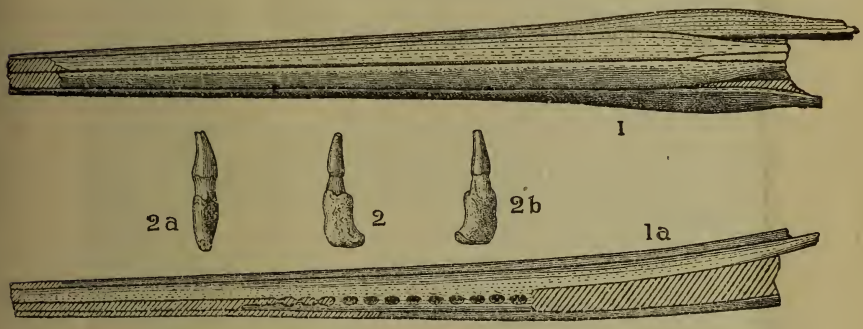


FIG. 4.—*Rhabdosteus latiradix* Cope (type); two-ninths natural size; original; from Miocene of Maryland. 1, muzzle from above; 1*a*, do. left side; 2, 2*b*, tooth from side; 2*a*. do. from edge. The posterior parts of the maxillary and premaxillary bones are restored from a different specimen from that represented in the rest of the figures. Teeth also separate; two-thirds natural size.

aa, Maxillary without vertical posterior crests.

Two teeth at the extremity of each mandibular ramus; *Berardius* Less.

Mandibular ramus with a terminal tooth; *Choneziphius* Duv.

Mandibular ramus with a median tooth; *Mesoplodon* Gerv.

As already remarked, the extinct sperm whales do not equal in dimensions the single recent species. Their teeth differ a good deal from those of the latter. Thus the American form, which Leidy called Orycterocetus, have the crowns quite slender, and the pulp-cavity large. They occur in the Miocene beds from

[4] *Physeterula* Van Ben.

[5] *Scaldicetus* DuBus [?]; *Balænodon* Owen.

[6] *Hyperoödon* Lacep.

Maryland to North Carolina. The species from the Miocenes of Belgium and Australia have the pulp-cavity very small. The Kogias or pigmy sperm whales are found in all southern and tropical seas. A single extinct species, the *K. dubusii* Van Ben. has been found in the Miocene beds of Belgium. *Hoplocetus carolinensis* Leidy is from the phosphatic deposits of South Carolina. But one extinct species of Anarnacus (Hyperoödon) (Fig. 5), has

FIG. 5.—*Anarnacus rostratus* Wenm, from a photograph taken at Newport, R. I.

been yet found (in Belgium), but species of Choneziphius are abundant in the Miocene beds of both Europe and North America, Five species have been described by Leidy from the South Carolina phosphatic beds, of which the most conspicuous is the *C. trachops*. Mesoplodon is represented in the same formations by one species, the *M. prorops* Leidy. A species of each genus still lives on the coast of the United States, the *Choneziphius semijunctus* Cope (Plate XX.), and the *Mesoplodon bidens* Sowerby.

The DELPHINIDÆ are preëminently a modern type (Fig. 6). They display a tendency to the reduction of the rib heads, which is completed in the whale-bone whales, and the nostrils are far posterior, and the nasal bones mere tuberosities. The dentition differs within moderate limits; the killers, as the carnivora of the sea, having it powerfully developed, while in the grampus and Globiocephalus many of the teeth are shed. Monodon develops a large incisor with which it breaks the ice in Arctic regions. The genera differ as follows:

I. Cervical vertebræ mostly distinct.

a, Incisors not differentiated.

Teeth few, caducous; *Delphinapterus*[7] Lac.

aa, Superior incisors of one side forming a straight tusk.

Teeth few, deciduous; *Monodon* Linn.

II. Cervical vertebræ mostly coössified.

A. Flippers short, with less than twelve phalanges in the second finger.

a, A dorsal fin.

Teeth few, very robust; palate not grooved; *Orca* Gray.

Teeth medium, numerous, acute; palate not grooved; *Lagenorhynchus*[8] Gray.

Teeth medium, numerous, acute; palate grooved; *Delphinus* Linn.

Teeth numerous; premaxillae elevated in front of nares; palate plane; *Sagmatias*[9] Cope.

Teeth few, easily shed; *Grampus* Cuv.

Teeth compressed, spatuliform; *Phocæna* Cuv.

aa, No dorsal fin.

Teeth numerous, not caducous; *Leucorhamphus*[10] Lillj.

Teeth flat, spatuliform; *Neomeris* Gray.

AA. Flippers long, falciform; index with twelve or more phalanges.

A dorsal fin; teeth few, caducous; *Globiocephalus* Gray.

[7] Beluga Gray.

[8] Tursiops and Prodelphinus Gerv.

[9] Dorsal fin unknown.

[10] Delphinapterus Less. nec Lacep.

But few species of this family are known from terranes of earlier than Pliocene age, and they belong to existing genera. Extinct species of Delphinapterus and Orca have been found in the Italian Pliocene, and of Orca and Globiocephalus in England. In North America the *Delphinapterus orcinus* has been described from the Miocene of North Carolina, and the *D. vermont-*

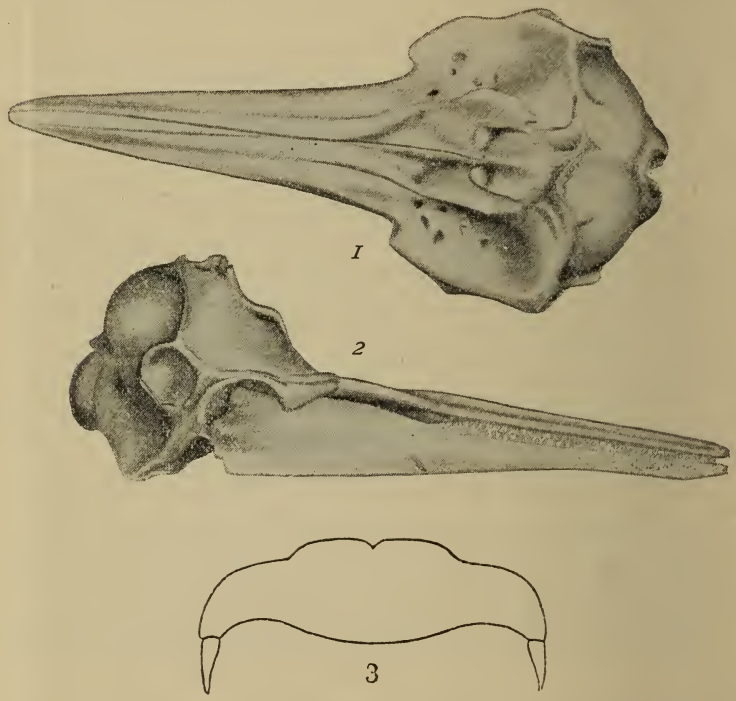


FIG. 6.—*Prodelphinus crotaphiscus* Cope (from type); 1, above, 2, from side; 3, section of muzzle. About one-fifth natural size.

anus has left its remains in the so-called Champlain clays of the drainage basin of the St. Lawrence river, which are perhaps of Plistocene age (Plate XXI.).

MYSTICETE.

This suborder embraces but a single family, the Balænidæ, whose characters may be summarized as follows:

Nareal canal oblique, overroofed by the short horizontal nasal bones, and underroofed by the elongate ptery-

goids; no longtitudinal or transverse crests of the skull; *Balænidæ.*

The family of the whalebone whales is represented by many species both recent and extinct. These fall into a number of natural genera, which display several affinities towards different extremes. Thus the fin-backs (Balænoptera) have developed speed through increased length of body; the humpbacks (Megaptera, have developed especial length of the fore limbs, while the right whales (Balæna) have acquired a huge oral cavity and the greatest length of whalebone. The fin-backs pursue and devour great numbers of fishes of small and medium dimensions, and their maw derives an especial capacity for containing them, through the presence of numerous expansible longitudinal folds of its inferior walls. The Balænæ, on the other hand, take in enormous quantities of water, which contains their minute molluscous food, and so enjoy an especial advantage in this direction,

Balænidæ are abundant in the Miocene, having an origin prior to that of the Dephinidæ. They would seem to have derived their descent from some form allied to the Squalodontidæ, since their nasal bones are more elongated than those of the Odontoceti, and in Plesiocetus the superior cranial bones show some of the elongation of that family. The genera of Balænidæ differ as follows:

I. Frontal and parietal bones elongated on the median line. Cervical vertebræ distinct; *Plesiocetus* Van Ben.

II. Frontal and parietal bones much abbreviated in the median line.

A, Cervical vertebræ all distinct; fingers four.

a, Numerous gular folds; vertebral canal not enclosed; [11] No coracoid; manus long; *Megaptera* Gray.[12] A coracoid; manus not elongate; *Cetotherium* Brandt.[13] Mandible with a long angle; coronoid large; *Herpetocetus* Van B.

[11] The external characters of Cetotherium and Herpetocetus are unknown.

[12] Poescopia Gray, Burtinopsis Van Ben.

[13] Eschrichtius Gray. Cetotheriophanes Brandt.

aa, Numerous gular folds; vertebral canal enclosed by diapophyses and parapophyses;

Both coracoid and acromion; manus short; a coronoid process; a dorsal fin; *Balænoptera.*[14]

aaa, Only two gular folds;

No dorsal fin; an acromion; *Rhachianectes* Cope.

aaaa, External characters unknown; maxillary bones very narrow.

Manus short; *Mesoteras* Cope.

AA. Cervical vertebræ more or less coössified.

Anterior three cervicals only united; *Palæocetus,* Seeley.[15]

All cervicals coössified; fingers five; no gular plicæ; no coronoid process; *Balæna,* Linn.[16]

The genus Plesiocetus is intermediate in its characters, and as it is generalized in structure, it is probably the ancestral type from which modern Balænidæ have been, by a process of differentiation, derived. Four species have been described from Belgium. The largest of these, *P. brialmontii* Van Ben., was some sixty feet in length; while the *P. brevifrons* Van B. and *P. affine* Van B. were twenty feet and less in length. Cetotherium is more nearly allied to Balænoptera (the finners). The number of species appears to have been considerable, several having been described from Southeastern Europe, one from Italy (*C. capellinii*), and others from Belgium and England. Corresponding species have been found in the Miocene beds of the Eastern States of North America. The *C. cephalus* Cope is about thirty feet in in length, the head being nine feet; and its flippers short. The ear bulla is noticeably compressed, somewhat incurved, and with a nearly parallelogrammic outline from the side; (Fig. 7). The skeleton was found in Charles Co., Maryland. (Plate XXII.) There have been described several species, probably of this genus, from the same region and horizon, of smaller size, the least, *C. pusillum* Cope, having been about fifteen feet in length.

[14] Physalus Gray.

[15] Eubalæna, Macleayius, and Halibalæna Gray; Balænula and Balænotus Van Ben.

[16] The difference between Neobalæna Gray and this genus is not yet known.

Species of Balænoptera and Megaptera occur in the European and probably in the American Miocenes. Those of Belgium correspond in various respects with the existing species. Thus *Balænoptera goropii* is compared by Van Beneden with the common existing finner, *B. musculus;* the *B. borealina* Van B. with the *B. borealis* of the Atlantic; and the *B. emarginata* Owen with the small pike whale, *B. rostrata.* Three species of Belgium and England are referred to the hump-backs, or Megaptera. A remarkable genus is Herpetocetus Van B., of which a single species of rather small size has been found in Belgium.

FIG. 7.—*Cetotherium cephalus* Cope, otic bulla. One-half natural size; original; from Miocene of Maryland.

Forms more or less nearly related to the right whales occur in Miocene beds on both sides of the Atlantic. Mesoteras Cope has the characters of the finner whales (Balænoptera) with the narrow maxillary bones of the true Balænæ. A large species with a skull of about eighteen feet in length was found by Prof. W. C. Kerr in Eastern North Carolina, and was named by the writer *Mesoteras kerrianus.* It is distinguished by an enormous thickening of the superciliary part of the frontal bone. The periotic bones are peculiar for their very short proportions, and balæni-form bulla. A small balænoid with only partly coössified cervical vertebræ has been found in the boulder clay of England and named *Palæocetus sedgwickii* by Prof. Seeley. The *P. insignis* Van Ben. from Belgium is also a small species. True Balænæ have been found in various parts of Europe.

In Western Europe three species are recorded from the Miocene, and two from later beds. Of the former, *B. affinis* Owen is similar in size and character to the right whale, *B. mysticetus*, and *B. primigenia* Van Ben. to the shorter headed type represented by the *B. cisarctica* of the middle Atlantic (Plate XXIII.). The *B. balænopsis* Van B. is not over twenty feet in length. In the Plistocene beds of Sweden a true Balæna of the *B. cisarctica* type has been discovered, and has been named *B. svedenborgiana.* It is thus evident that many species of whalebone

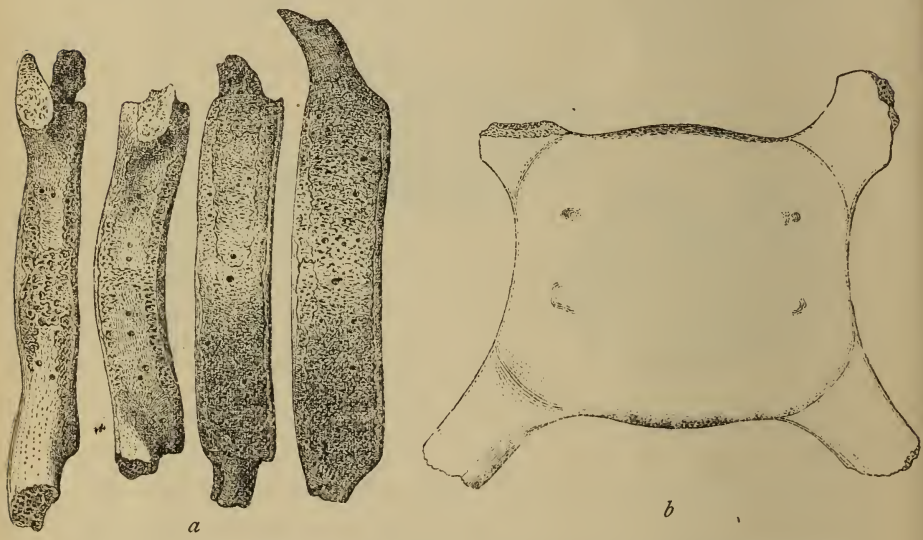


FIG. 8.—*Cetotherium cephalus* Cope, two-fifths natural size; individual represented in Fig. 7. Original; from Miocene of Maryland.

whales have become extinct, some of them in comparatively modern times. Such is the *Cetotherium robustum* Lilljeborg, which is known from a few fragments, not fully fossilized, from an island in the Baltic, and from Cornwall, England.

List of the Extinct Cetacea of North America.

BASILOSAURIDÆ, ... 3

Basilosaurus cetoides Owen. Ala., Miss.
Doryodon serratus Gibbes. Ala., Fla.

SQUALODONTIDÆ, ... 6

Squalodon atlanticus Leidy. N. J., Md.
" *vinearius* Leidy. Mass. (Martha's Vineyard.)
" *holmesii* Leidy. S. C.
" *pelagius* Leidy. S. C.
" *pygæmus* Müller. S. C.
" *protervus* Cope. S. C.

PLATANISTIDÆ. 19

Delphinodon mento Cope. S. C.
" *wymanii* Leidy. S. C.
" *venustus* Leidy. S. C.
Lophocetus calvertensis Harlan. Md.
Priscodelphinus grandævus Leidy (=*P. harlani* Leidy). N.J.
" *lacertosus* Cope. Md.
" *gabbii* Cope. Md.
" *uræus* Cope. N. J.
" *ruschenbergerii* Cope. Md.
Zarhachis flagellator Cope. Md.
" *tysonii* Cope. Md.
" *velox* Cope. N. J.
Ixacanthus cœlospondylus Cope. Md.
" *spinosus* Cope. Md.
" *atropius* Cope. Md.
" *conradi* Leidy. Va., Md.
" *stenus* Cope. Md.
Rhabdosteus latiradix Cope. Md.
Agabelus porcatus Cope. N. J.

INCERTÆ SEDIS. 2

Cetophis heteroclitus Cope. Md.
Saurocetus gibbsii Agass. S. C.

PHYSETERIDÆ. 10

Physeter vetus Leidy. N. C.
" *cornutidens* Leidy. N. C., Md.
" *quadratidens* Leidy. N. C.
Hoplocetus obesus Leidy. S. C.
Choneziphius trachops Leidy. S. C.

Choneziphius liops Leidy. S. C.
" *cœlops* Leidy. S. C.
" *macrops* Leidy. S. C.
" *chonops* Leidy. S. C.
Mesoplodon prorops Leidy. S. C.

DELPHINIDÆ. 2

Delphinapterus vermontanus Thompson. Vt., Canada.
" *orcinus* Cope. N. C.
Dephinus occiduus Leidy. Cal.

BALÆNIDÆ, ... 10

Cetotherium pusillum Cope. Md.
" *expansum* Cope. Md.
" *priscum* Leidy. Va.
" *polyporum* Cope. N. C.
" *mysticetoides* Emmons. N. C.
" *cephalus* Cope. Md.
" *leptocentrum* Cope. Va.
Balænoptera palæatlantica Leidy. Va.
" *davidsonii* Cope. Cal.
Mesoteras kerrianus Cope. N. C. —

Total number of species, ... 52

EXPLANATION OF PLATES.

PLATE XX,—*Choneziphius semijunctus* Cope. One-tenth natural size. From photographs of the type in the Museum of Charleston, S. C., taken by Lieut. Vogdes, U. S. A. Fig. 1. Cranium from above; 2, cranium from below; 3, extremity of the mandible, with teeth.

PLATE XXI.—*Delphinapterus leucas* Pallas. One-thirteenth natural size. From a skeleton in the Museum of the Academy of Natural Sciences of Philadelphia, obtained by Dr. I. I. Hayes, from Baffin's Bay. Type of *Beluga concreta* Cope.

PLATE XXII.—*Cetotherium cephalus* Cope. Restoration, one-eighteenth natural size; the portions shaded are the actual specimens of one individual found in the Miocene of Maryland, and now in the Museum of the Academy of Natural Sciences of Philadelphia. Described by E. D. Cope in its Proceedings, 1867, p. 148.

PLATE XXIII.—*Balæna cisarctica* Cope. Type specimen as mounted in the Museum of the Academy of Natural Sciences of Philadelphia; one-thirty-seventh natural size. Fig. 1, side view; Figs. 2, 3, 4, periotic bones from side, end, and below; Fig. 5, cervical vertebræ, oblique inferior view.

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Compliments of Author.

(24)

SYLLABUS OF LECTURES

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PALEONTOLOGY

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PROFESSOR OF GEOLOGY AND PALEONTOLOGY IN THE UNIVERSITY OF PENNSYLVANIA.

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PART III.

PALEONTOLOGY OF THE VERTEBRATA.

INTRODUCTION.

In the following pages the attempt is made to bring together the information which we possess as to the characters of the divisions of the Vertebrata above families which are available for the determination of their relations by the paleontologist. These characters, which are of necessity those of the hard parts, must be of the first importance to the discovery of the phylogenies, since the soft parts are unavailable. It is, however, true that the relations of these are close enough to render our inferences from the former generally safe. Fortunately, also, the living remnants of extinct groups are sufficiently numerous to enable us to check our studies of the osteology. Thus we have the Branchiostoma, the lampreys, the Ceratodus and Lepidosiren, the Sphenodon, and the Monotremata, to which to refer when we desire to learn approximately the characters of the soft anatomy of ancient forms.

All the characters of the various divisions are not given. In fact, when all extinct forms come to be known, no division is likely to be defined by more than one character. At present several characters may be often ascribed to various divisions, but one of these will ultimately prove to be the essential one. It is the object of the present synopsis to bring these definite characters into prominence; hence they are always stated first. The method of keys is adopted as the most perspicuous method of exhibiting them.

We are embarrassed in the endeavor to present the relations of the earliest and lowest Vertebrata by a want of knowledge of their structure, and by the absence from our collection of numerous intermediate forms which must have existed. Until our knowledge is more complete, the arrangement, especially of the contents of the class Agnatha, must be regarded as largely provisional.

The ossification of the skeleton of the Vertebrata has developed first on the exterior of the head and body and in the sheath of the chorda dorsalis, and has then penetrated inwards. The limbs have preceded in time the arches (scapular and pelvic) to which they are, in the higher forms, attached. Hence we find in such genera as Cephalaspis and Bothriolepis pectoral limbs without a scapular arch, but with merely dermal ossifications to which they are attached. This is parallel to the general absence of most of the pelvic arch in fishes. The limbs themselves are supposed to be radial ossifications in primitive longitudinal folds of the body integument, some of which remain in large part, as the dorsal fin of various fishes; while more frequently but few of the radii remain, as in the limbs of most Vertebrata. (Fig. 1.)

The use of this syllabus presupposes a knowledge of the rudiments of vertebrate anatomy. The subject is presented in zoological order, but tables are given, in which the taxonomic divisions are represented in their statigraphic position and succession.

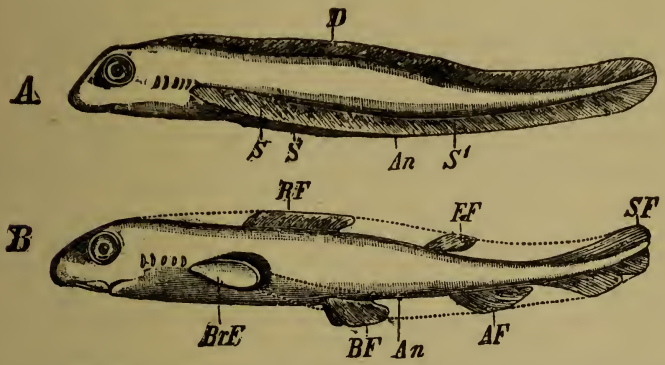


FIG. 1.—Diagrammatic representation of primitive and derivative types of lateral and median fins. *A*, primitive condition, fins continuous; *B*, derivative condition, fins distinct and specialized. *D*, dorsal fin; *BrF*, pectoral; *BF*, ventral; *AF*, anal; *SF*, caudal; *RF*, dorsal; *FF*, second dorsal fin. From Wiedersheim.

The branch Vertebrata is divided into the following superclasses:

No skull nor skeleton; notochord short, anterior, temporary; nervous center a longitudinal cord; *Hemichorda.*

No skull nor skeleton; notochord caudal only; nervous center a ganglion; *Urochorda.*

No skull; notochord extending throughout the body, included in a membranous sheath, as is the cord-like nervous axis above it; *Cephalochorda.*

A cartilaginous or bony skull and skeleton, which extends throughout the body; central nervous system a longitudinal cord terminating in a brain within the skull; *Craniata.*

Superclass I.—HEMICHORDA.

There is but one class of Hemichorda:

Not metameric; no mantel; respiratory fissures on each side of the pharynx; alimentary canal with openings at opposite extremities of body; *Enteropneusta.*

Class I.—ENTEROPNEUSTA.

But one order of this class is as yet known:

No appendages to the body except an oval mass extending in front of the head; *Helminthophya.*

The order HELMINTHOPHYA embraces but one family, the Balanoglossidæ, which includes species of worm-like form, which burrow in the soil of the sea coast below high tide. No extinct species of Hemichorda are known.

Superclass II.—UROCHORDA.

There is but one class of Urochorda:

Not metameric; a mantel covering the body; respiration pharyngeal; heart distinct, saccular; *Tunicata.*

Class I.—TUNICATA.

There are two orders of Tunicata:

Inhalent and exhalent openings close together; alimentary canal elongate; *Ascidiæ.*

Inhalent orifice and anus at opposite extremities; alimentary canal crowded into a body termed a nucleus; *Thaliacea.*

To the ASCIDIÆ belong the families Appendiculariidæ, Clavellinidæ, Ascidiidæ, Botryllidæ, Didemnidæ, Polyclinidæ, and Pyrosomidæ. To the THALIACEA are referred the families Salpidæ and Doliolidæ.

Some of the Tunicata are free-swimming, and these may consist of single or conjoined individuals. Others are attached, some by a peduncle and others sessile, separately or in colonies. No extinct species of Urochorda are known.

Superclass III.—CEPHALOCHORDA.

The only class of the Cephalochorda is the following:

No mantel; walls of the body muscular myotomes; no jaws nor extremities; pharyngeal walls fissured; heart a longitudinal vessel, which gives off branchial vessels, which unite into an aorta; a liver and vena cava present; *Acrania.*

Class I.—ACRANIA.

Of this class but one order is as yet known:

Pharyngeal fissures enclosed externally by a fold of the integument, which encloses a chamber (atrium) which opens inferiorly; openings of alimentary canal at opposite extremities; heart tubular; *Leptocardii.*

The species of the Branchiostomidæ (the lancelets) are of compressed, worm-like form, and burrow in the soil of the shores of all oceans. No fossil remains of them have been yet found.

Superclass IV.—CRANIATA.

The five classes of the Craniata are defined as follows:

I. No lower jaw nor pectoral arch.

Internal skeleton not ossified; — *Agnatha.*

II. Lower jaw and pectoral arch present.

a, Basicranial axis not ossified; vertebral column consisting chiefly of intercentra.

Limbs represented by many-radiate fins, which are also present on the median lines of the body; a coracoid bone; heart with two chambers; one or no occipital condyle; no internal nares; — *Pisces.*

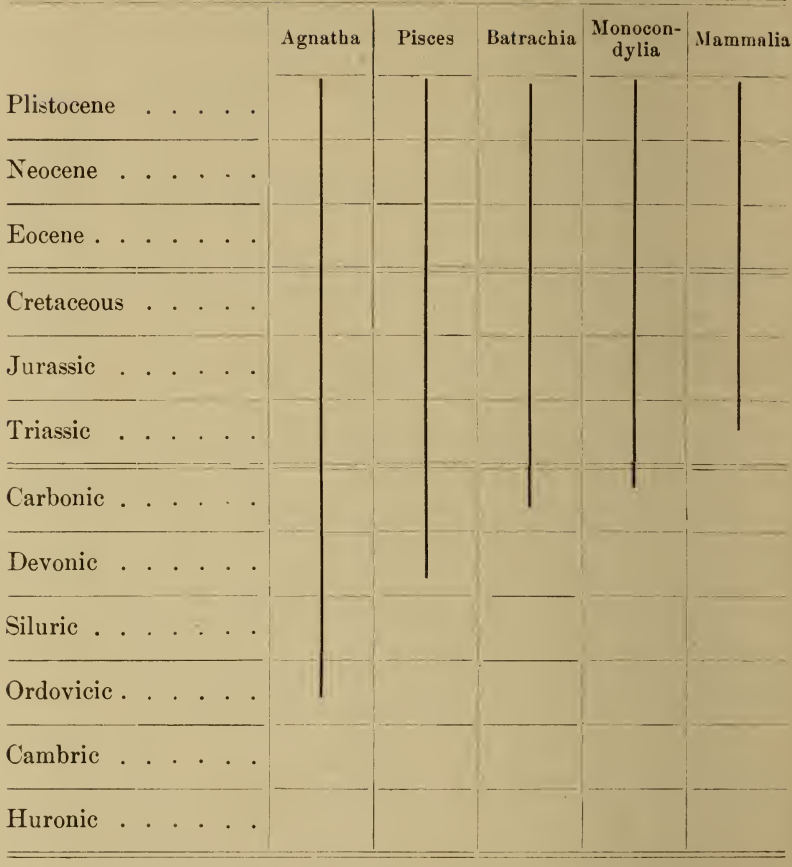
Limbs consisting of one basal element, two propodials, and metapodials and digits; no median fins; lower jaw attached to a suspensorium, complex; no opercular bones; a coracoid; heart with three chambers; two occipital condyles; internal nares; — *Batrachia.*

aa, Basicranial axis ossified; vertebral column consisting chiefly of centra; an amnion and allantois.

Limbs as in Batrachia; one occipital condyle; a suspensorium of the lower jaw; mandible segmented; ankles between first and second rows of carpal and tarsal bones; heart with three or four chambers; — *Monocondylia.*

Limbs as in Batrachia; two occipital condyles; no suspensorium of the lower jaw; mandible not segmented; ankles between propodial bones and carpus or tarsus; heart with four chambers; — *Mammalia.*

The period of appearance and duration of each of these classes is exhibited in the accompanying table. It will be observed that the order of appearance corresponds with the natural order of structural complexity, the simplest appearing earliest and the most complex last. It must be mentioned that it is probable that each of the classes appeared a little earlier than the time assigned them in this table. The discovery of the fossil remains is regarded as the first positive indication of the presence of a species of a given class. Spines uncertainly referred to sharks (Pisces) have been found in the Middle and Lower Siluric in Europe and North America respectively. Foot impressions probably of Batrachia have been found in the Carbonic at lower horizons than the bones. Tracks probably of birds have been found in the Trias. A fore limb probably of a mammal has been found in the Permo-Triassic Karoo formation of South Africa.



Class I.—AGNATHA.

The known members of the class Agnatha are a very small representation of those that once existed; and they present a great variety of characters, having little affinity with each other. Two subclasses are most distinctly indicated:

An osseous dermal skeleton with lateral limb-like appendages; *Ostracophori.*

No osseous skeleton nor lateral limb-like appendages; *Marsipobranchii.*

Of the Agnatha, extinct species of the subclass Ostracophori only are known.

Subclass I.—OSTRACOPHORI.

There are three orders of this subclass, as follows. In none of them are nostrils present.

No pectoral appendages; exoskeleton in three layers,—the internal lamellar, the middle cancellous, the external vaso-dentine; no bone-corpuscles; *Heterostraca.*

No pectoral appendages; exoskeleton in three layers with bone-corpuscles, the middle layer with vascular canals; *Osteostraca.*

Pectoral appendages; exoskeleton osseous; with sensory grooves; *Antiarcha.*

The time of appearance and range in time of these orders is displayed in the following table. They are all Paleozoic.

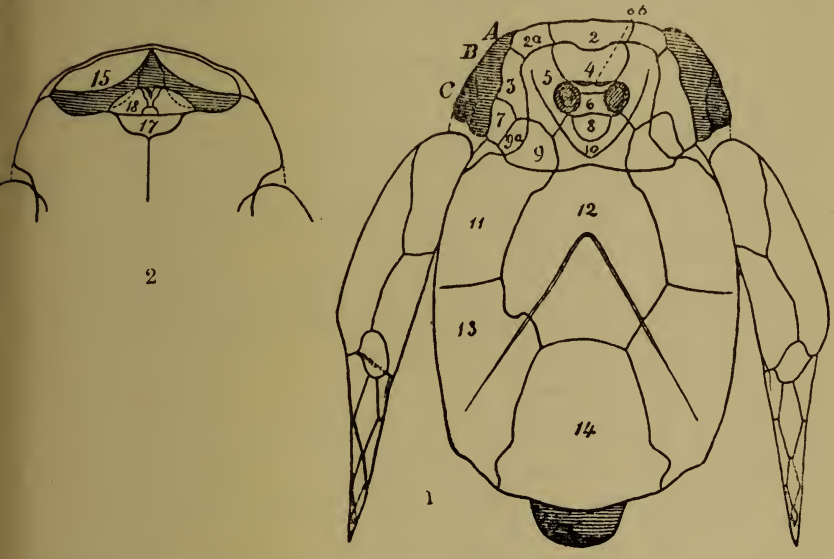


FIG. 2.—*Bothriolepis canadensis* Whiteaves; head and carapace, from above, and head from below. From the Devonic of New Brunswick. From Whiteaves. (Antiarcha.)

	Heterostraca.	Osteostraca.	Antiarcha.
Carbonic			
Devonic			
Siluric			
Ordovicic			
Cambric			

The oldest Craniata are from the Ordovician (Trenton) of Canyon City, Colorado, N. America, and some of them are supposed to be Heterostraca until proven to be something else. The first positively identified forms are from the Salina of Pennsylvania and the Ludlow rocks of England, which have produced Heterostraca. The Osteostraca appear first in the Ludlow beds in England, and extend to the Lower Devonic (Old Red Sandstone). They appear first in America at the latter horizon in New Brunswick. The Antiarcha commence in the Old Red, and continue into the Chemung of the Lower Carbonic system. The principal genus of the Heterostraca is the Pteraspis; of the Osteostraca is the Cephalaspis; and of the Antiarcha is the Pterichthys. (Fig. 2.)

Subclass II.—MARSIPOBRANCHII.

This subclass has two orders:

Branchial fissures communicating directly with the pharynx; nasal sac perforating the palate; *Hyperotreti.*

Branchial fissures communicating with a common branchial passage which opens into the pharynx; nasal sac not perforating palate; *Hyperoarti.*

To the HYPEROTRETI belong two families, the Myxinidæ and the Bdellostomidæ; to the HYPEROARTI one, the Petromyzontidæ.

No extinct species of Masipobranchii are known. They include only the recent lampreys and hags.

Class II.—PISCES.

This class is divided into four subclasses:

I. No suspensorium of the mandible.

No dermal cranial ossifications; ventral claspers; no opercular bones; no maxillary arch; *Holocephali.*

Dermal cranial ossifications and opercular bones; no claspers; no maxillary arch; *Dipnoi.*

II. A suspensorium of the mandible;

No dermal cranial ossifications, maxillary arch, nor opercular bones; claspers present; *Elasmobranchii.*

Dermal cranial ossifications and opercular bones; no claspers; a maxillary arch; *Teleostomi.*

With our present knowledge we find the first appearance of these subclasses to be contemporary; *i. e.*, in the earlier part of the Devonic system, in the Corniferous Limestone and its equivalents in other parts of the world. Spines, possibly belonging to sharks (Onchus), have been found in the Lower Siluric (Clinton) in Pennsylvania, and the Upper Siluric (Ludlow) in England, but the animals to which they belong may not have been Pisces. The Devonic forms referred to the Dipnoi (the Arthrodira), while probably belonging to that subclass, are not yet positively proven to be such. Representatives of all four sub-

classes still exist. The Holocephali are seen in the Chimæras; the Dipnoi in the lung-fishes; the Elasmobranchii in the sharks and rays; and the Teleostomi in the true fishes.

The primary divisions of the fishes, as above indicated, are seen in the structure of the skull. After this the structure of the fins demands attention. Some of the peculiarities of fin structure are common to all the members of a subclass, while others characterize subdivisions of the same. These members consist of a dermal portion and a skeletal portion. The former is external to the body walls; the latter is internal to those walls in the case of the median fins, and external in the paired fins, when present. The skeletal portion consists of two sets of segments. First those to which the dermal rays or folds are attached are called the basilars. These are articulated to a second set, the axials. The segments are then termed the baseosts and axonosts. In the paired fins the latter are articulated directly with the elements of the shoulder and pelvic girdles. Of the latter only the pubic element is present in Teleostomi. In the shoulder girdle we have elements termed scapula, coracoid, clavicle, and epiclavicle. There is sometimes an interclavicle. The dermal portion of the fins may include as sup-

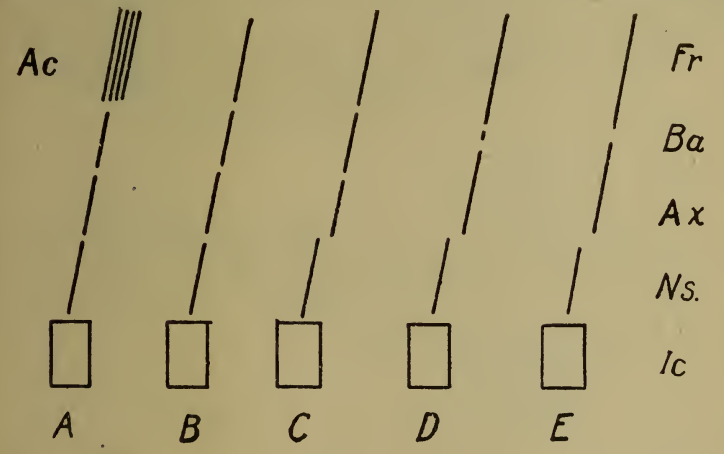


FIG. 3.—Diagrams of actinophores; *A*, entotetramerous; *B*, ectetramerous; *C*, *D*, ectrimerous; *E*, ecdimerous; *Ac*, actinotrichia; *Fr*, fin-rays; *Ba*, baseost; *Ax*, axonost; *Ic*, intercentrum.

ports certain "fin-rays," or it may include only hair-like rods or "actinotrichia." The latter characterize primitive types. In the case of the median fins it is characteristic of primitive fishes to have the baseosts and axonosts articulated with the neural spines of the vertebræ. In modern fishes the axonosts are not so articulated, and do not correspond with them, while the baseosts are rudimental or wanting. (Fig. 3.)

Remarkable modifications take place in the successive evolution of the caudal fin. The primitive condition of the vertebral column in the tail of a fish is straight, with spines equally divergent above and below. This is the diphycercal tail (Fig. 4, *A*). It persists in some modern fishes;

e. g., the eels. In the next stage the axis is turned up at the end, and the spines of the inferior side are spread out fan-like, while those of the superior side are crowded together. The dermal part of the fin may develop an angle on the inferior spines (hæmal spines), the result being a two-lobed fin, in which the upper lobe is much larger than the lower. This is the heterocercal tail (Fig. 4, *B*, *C*, and *D*). In later forms the hæmal spines grow larger and the neural spines smaller, and the axis grows shorter by the abortion of the terminal centra. As a result, the lobes of the caudal fin become equal. In the most fully developed types the hæmal spines fuse into a fan-shaped bone which supports the fin. This is the homocercal caudal fin (Fig. 3, *E*). In its growth it generally passes through the diphycercal and heterocercal stages before reaching maturity.

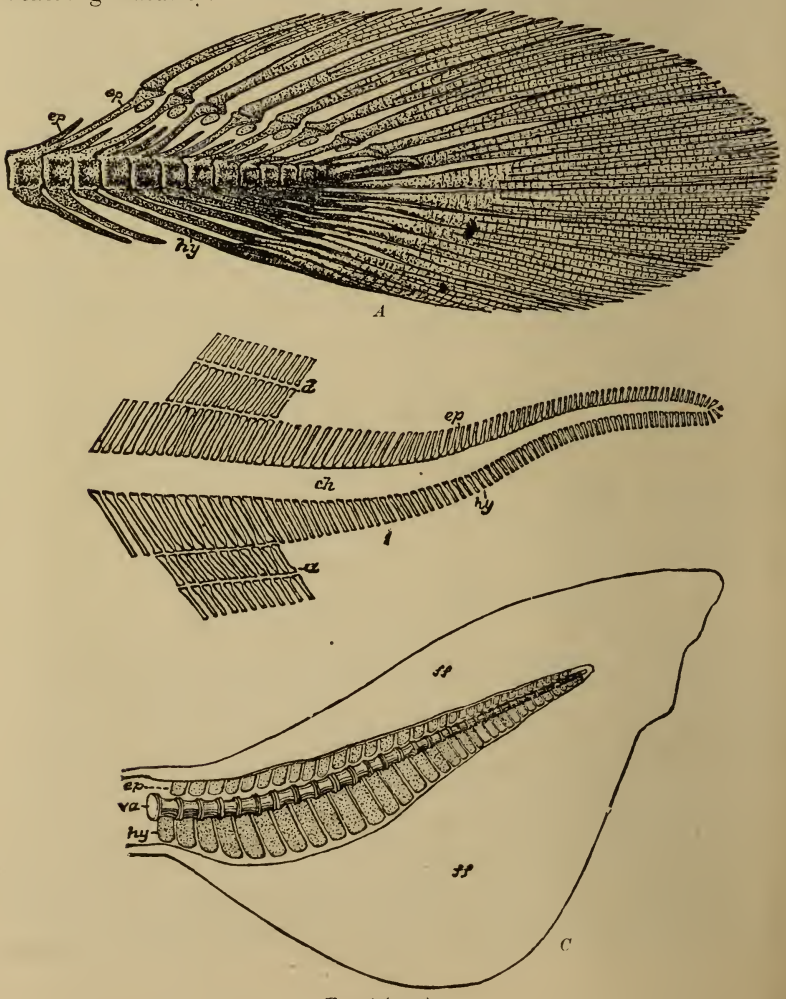


FIG. 4 (over).

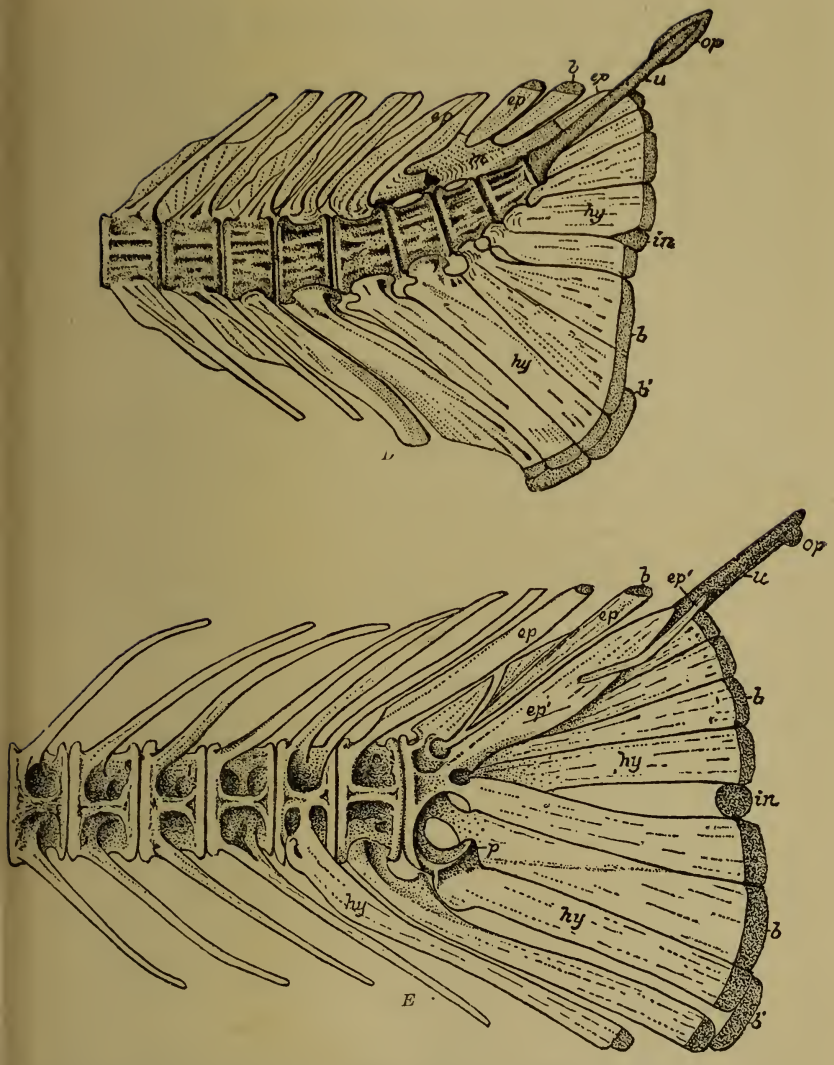


FIG. 4.—Tails of fishes; *A*, diphycercal tail of Polypterus; *B*, diphyheterocercal tail of Coccosteus; *C*, caudal fin of a shark (Centrina); *D*, end of vertebral column of trout (*Salmo fario*); *E*, end of vertebral column of barbel (*Barbus fluviatilis*); *ep*, Epural; *hy*, hypural bones.

Subclass I.—HOLOCEPHALI.

But one order of this subclass is known:

A single external branchial fissure; actinotrichia present; basilars, axonosts, and neural spines articulating with

each other; pectoral fin pluribasal, with three axonosts and numerous basilars; ventrals with elongate axonosts and basilars; *Chimæroidei.*

In all known CHIMÆROIDEI the teeth are large paired bodies, one pair in the lower and two in the upper jaws, composed of coarse vascular dentine. These contain columns varying in number and shape, consisting of coarse tubes with calcareous walls which terminate on the masticating surfaces. Notochord persistent, the ossifications, when present, consisting of delicate rings, more numerous than the neural arches. In the existing forms the males have claspers like those of sharks.

Chimæroidei appear in the Corniferous Limestone in Ohio, Wisconsin, and Iowa, and in the Eifel Limestone in Rhine Prussia. They are found in Triassic and Jurassic beds in Europe, and abound in the Cretaceous of Europe and North America, and New Zealand They extend through the Cenozoic beds of Europe and North America, and a few species still exist. The known families are the Ptyctodontidæ (of doubtful reference), the Squalorajidæ, Myriacanthidæ, and Chimæridæ, the last named only still remaining alive, in three genera.

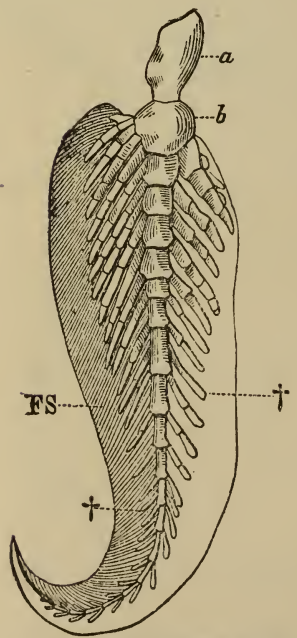


FIG. 5.—*Ceratodus forsterii* Krefft; pectoral fin, unibasal type; *a*, *b*, axial elements; †, radials; *FS*, actinotrichia. From Wiedersheim.

Subclass II.—DIPNOI.

Two orders of this subclass are known, as follows:

Paired fins rudimentary or absent; pelvic elements (so far as known) double, lateral; body more or less protected by plates; *Arthrodira.*

Paired fins archipterygial (*i. e.*, unibasal); pelvic elements fused on the middle line; body without bony plates (Fig. 5); *Sirenoidea.*

The ARTHRODIRA are represented by three or four families, the Coccosteidæ, the Asterosteidæ, and the Mylostomidæ, all restricted to the periods of the Devonic system. Their remains abound in these horizons of Europe and North America. They possess behind the head a segmented dorsal plate and a compound ventral plate or plastron. The anterior lateral superior plates articulate with the posterior lateral cranial elements by a hinge-like joint. Notochord persistent. These forms have some resemblance to the Agnatha Antiarcha, but they have a well-developed mandibular

arch, and distinct pelvic elements. Their teeth are processes of the edges of the jaws.

The SIRENOIDEA commence in the Carbonic system and continue to the present day, when representatives of two genera, Ceratodus and Lepidosiren, exist in the fresh waters of the Southern Hemisphere. The families are four, the Dipteridæ, Phaneropleuridæ, and Ctenodontidæ where the skull is covered with small tessellated plates, and the Lepidosirenidæ, where the bones of the skull are few and large. The Dipteridæ and Phaneropleuridæ are confined to the Devonic, and the Ctenodontidæ to the Carbonic. The Lepidosirenidæ commence in the Permian (Texas) and continue to the present time. The teeth of Sirenoidea are plates with radiating ridges, or else processes of the jaws.

Subclass III.—ELASMOBRANCHII.

The sharks are divided into three orders, as follows:

Paired fins unibasal and archipterygial; a basioccipital element; *Ichthyatomi.*

Paired fins pluribasal (with three axonosts); no basioccipital; *Selachii.*

Paired fins sessile, with a single skeletal element of uncertain homology; *Acanthodii.*

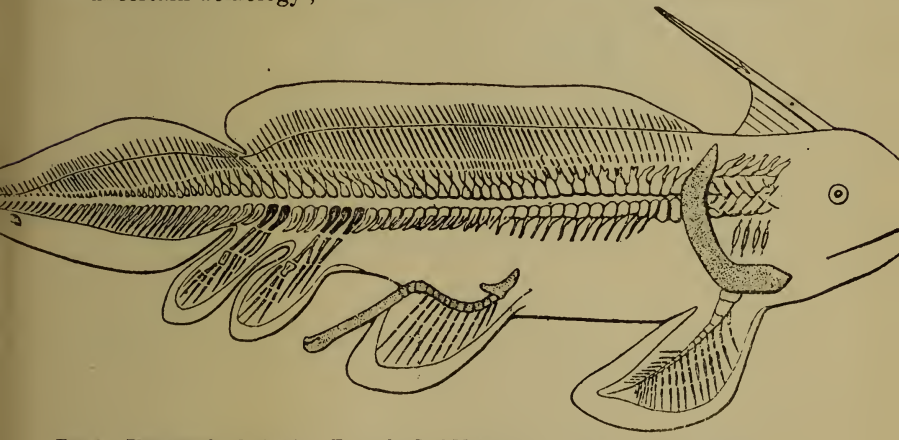


FIG. 6.—*Pleuracanthus lucius* Ag. From the Coal Measures of Alsace. From Sauvage.

In the ICHTHYOTOMI the notochord persists, and the centra are represented by segments; the neural spines, axonosts, and baseosts are continuous, and the dermal rays are actinotrichia (that is, hair-like and more numerous than the baseosts). There are are two families, the Pleuracanthidæ and the Cladodontidæ, which differ in the form of the pectoral fin. In the former they are biserially pinnate (Fig. 6), while in the latter they are uniserially pinnate (branches (baseosts) on one side of the axis (axonosts) only). The Pleuracanthidæ have teeth with

two principal equal cusps, while the Cladodontidæ have a principal median cusp, with or without smaller lateral cusps. The Ichthyotomi are all confined to the Carbonic system.

The SELACHII (sharks and rays) present two lines of relation, or sub-orders, which differ as follows:

Vertebræ, when developed, having the concentric laminæ predominating over the radiating laminæ; anal fin absent; *Tectospondyli.*

Vertebræ when developed, with the radiating laminæ predominating over the concentric; anal fin present; *Asterospondyli.*

In the *Tectospondyli* the majority of living types have the body depressed, so that the branchial fissures are on the inferior surface. This

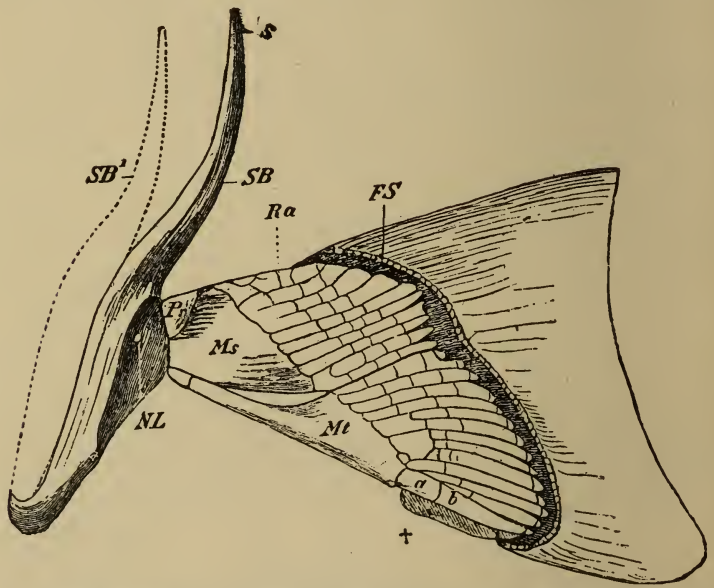


FIG. 7.—*Heptanchus griseus*, left pectoral fin, pluribasal type; *SB*, scapular arch; *NL*, foramen; *Pr*, propterygium; *Ms*, mesopterygium; *Mt*, metapterygium; *a*, *b*, axis of metapterygium, *Ra*, basilars; *FS*, actinotrichia. From Wiedersheim.

type is seen in the skates, saw-fishes, and rays. In the *Asterospondyli*, on the other hand, the branchial fissures are lateral. There are several families of Tectospondyli, which appeared at different periods of geological time. They are as follows:

I. Teeth in the usual jaws.

α, The crowns of the teeth closely overlapping each other like shingles.

Edges of crowns forming a grinding face; (1) *Petalodontidæ.*

αα, The crowns of the teeth not overlapping;

β. Summits of crowns forming a grinding surface.

(2) *Psammodontidæ;* (3) *Rajidæ;* (4) *Rhinobatidæ;* (5) *Trygonidæ;* (6) *Myliobatidæ* (eagle rays).

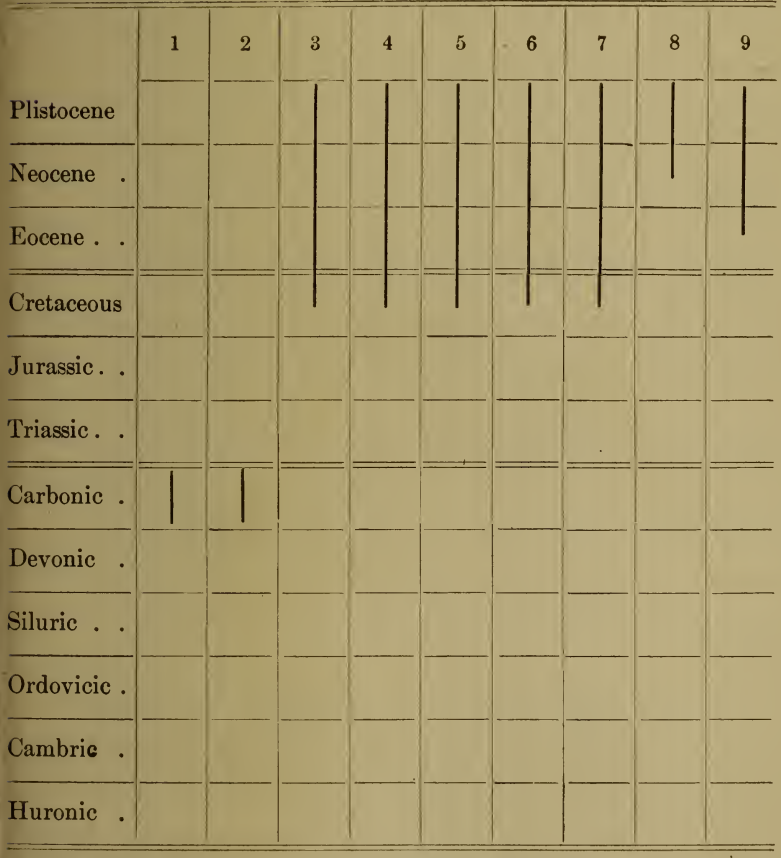
ββ, Summits of crowns elongate cusps.

Body not flattened; (7) *Spinacidæ.*

II. Teeth in a produced muzzle.*

(8) *Pristiophoridæ;* (9) *Pristidæ* (saw-fishes).

These families have the following range in geological time:



The families of the Asterospondyli differ as follows:

I. Teeth molariform.*

Teeth separate; (1) *Cestraciontidæ.*

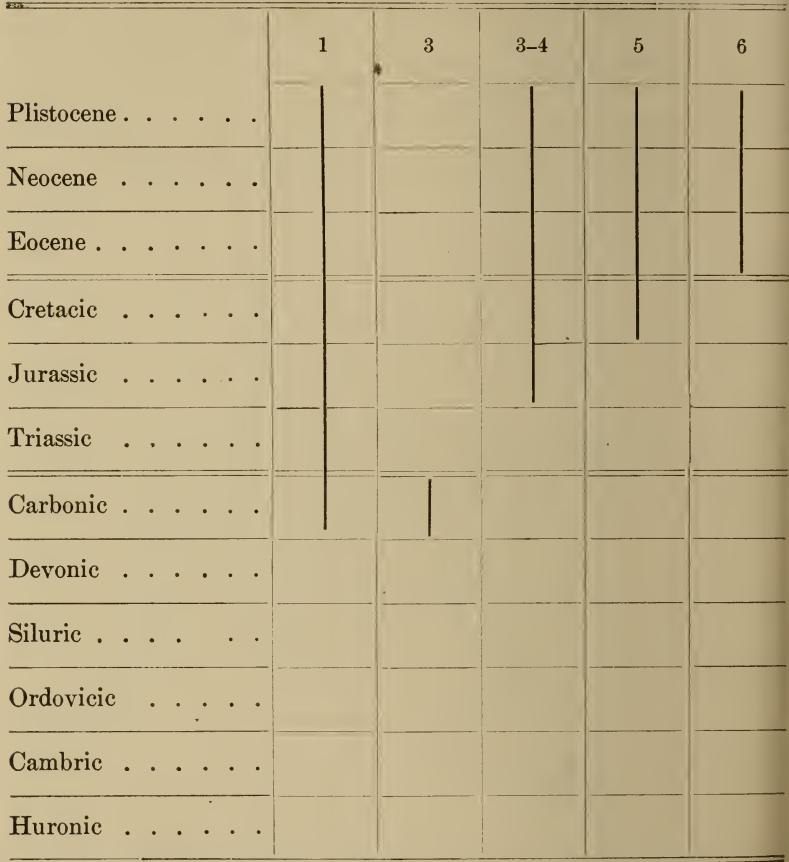
Teeth confluent; (2) *Cochliodontidæ.*

II. Teeth with elevated cusps.

(3) *Hexanchidæ;* (4) *Scylliidæ;* (5) *Lamnidæ.* (6) *Carchariidæ;*

* Except some Cestraciontidæ.

The distribution of these families in time is as follows:



From these tables it appears that the Selachii with grinding teeth are prior in geological age to those with teeth especially appropriate to a carnivorous diet. The latter reached their greatest perfection, as well as size and numbers, in the Neocene system, some of the Carcharodons having been probably seventy feet in length.

All the families of Elasmobranchii are common to the Old and New Worlds.

The order ACANTHODII possesses a specialized type of paired fins, more like those of the higher fishes than is found in other Elasmobranchii. The vertebral axis is notochordal, and the fins do not display any actinotrichia or rays. The males have no claspers. Tail heterocercal. In the known genera the fins are supported by a large spine in the anterior border of each; and the integument is covered with small quadrate granules, which also extend over the fins. The teeth are

absent or minute, or consist of a single compressed triangular cusp. The known species are of rather small size.

The Acanthodidæ has but one dorsal fin, while the Ischnacanthidæ and Diplacanthidæ have two. In the Diplacanthidæ only have clavicles been observed; in the other two families they are wanting. Among Diplacanthidæ the genus Climatius is remarkable in having a series of spines on each side between the ventral and pectoral fins, which indicate the position of the primitive lateral fold, from which the paired fins are supposed to have been derived.

Diplacanthidæ are Devonic, as are also Ischnacanthidæ. The Acanthodidæ belong to the Devonic and Carbonic.

Subclass IV.—TELEOSTOMI.

There are four superorders of the Teleostomi or true fishes, which differ in the structure of the fins:

I. Median fins each with a single bone representing axonosts.
Paired fins unibasal; *Rhipidopterygia.*

II. Median fins with numerous axonosts.
Paired fins with baseosts; pectorals with axonosts, which are distinct from baseosts; *Crossopterygia.*
Paired fins with baseosts; pectoral fins with axonosts and baseosts confounded; pluribasal; *Podopterygia.*
Pectoral fins only with baseosts, these confounded with axonosts, and pluribasal; *Actinopterygia.*

Superorder Rhipidopterygia.

The orders of Rhipidopterygia are the following. They all have actinotrichia in place of fin-rays.

I. Paired fins with the basilars arranged on each side of the median axis, or archipterygial.
Median fins with basilars; *Taxistia.*

II. Paired fins with the basilars arranged fan-shaped at the end of the short axis.
Median fins with basilars; *Rhipidistia.*
Median fins without, caudal fin with, basilars; *Actinistia.*

The Taxistia includes but one family, the Holoptychiidæ, which is of Devonic age. The Rhipidistia includes the Tristichopteridæ, from the Devonic and Carbonic; the Osteolepidæ, from the same; and possibly the Onychodontidæ, which are Devonic.

The Actinistia includes the single family of the Cœlacanthidæ, which appears in the Lower Carbonic and ranges to the Upper Cretacic, in both Europe and America. (Fig. 8.)

In all of the Rhipidopterygia the tail is either heterocercal or diphycercal, and the chorda dorsalis persists. The scales have a layer of ganoine, which extends also on the head. The latter has a well-defined, persistent transverse suture separating the parietal from the frontal elements.

Superorder Crossopterygia.

The superorder Crossopterygia includes two orders, as follows:

Baseosts and axonosts well developed; actinotrichia; no fin-rays; pectorals ? unibasal; *Haplistia.*

Baseosts rudimental; fin-rays; pectorals tribasal; *Cladistia.*

But one family is included in the Haplistia, the Tarasiidæ, from the Lower Carbonic of Scotland. The Cladistia are represented by a family which is not known in the fossil state, the Polypteridæ of the rivers of Africa. The vertebræ in this genus are ossified and biconcave.

Superorder Podopterygia.

The superorder Podopterygia has also two orders. They are thus defined:

Branchiostegal rays present; *Lysopteri.*

No branchiostegal rays; *Chondrostei.*

Fig. 8.—*Undina penicillata* Münst. (Cœlacanthidæ); one-third natural size, showing rhipidopterygian and actinistious types of fins; *j*, jugular plates; *b*, scales of *Undina acutidens*. From Zittel.

In these orders the notochord is persistent, and there are either actinotrichia, or fin-rays which are more numerous than the baseosts. Tail heterocercal or diphycercal.

The Lysopteri includes four families, which differ as follows:

I. Tail heterocercal.

Teeth acute, external; *Palæoniscidæ.*

Teeth obtuse, on palate and splenial; *Platysomidæ.*

No teeth; *Chondrosteidæ.*

II. Tail diphycercal.

Teeth present; scuta on body; *Belonorhynchidæ.*

The Paleoniscidæ range from the Devonic to the Jurassic inclusive; the Platysomidæ belong to the Carbonic exclusively; the Belonorhynchidæ to the Trias; and the Chondrosteidæ to the Jurassic.

The Chondrostei are degenerate representatives of the Podopterygia. They are deficient in various normal ossifications, and have an additional series of membrane bones in the middle line of the skull. The two families are the Accipenseridæ, or sturgeons, and the Polyodontidæ, or paddle-fishes. Both are represented at the present day in the northern regions of both hemispheres, and both appear first in geological time in the Eocene system.

Superorder Actinopterygia.

In this superorder we have the finally specialized type of the true fishes. This consists in the abbreviation of the skeletal parts of the true fins, so that the basilar elements become sessile on the scapular. Coincidentally with this result, the fin-rays of the median fins become distinctly developed and articulated each with its corresponding baseost or axonost. Fishes of this superorder have, for the most part, homocercal tails, the superior lobe being contracted to the size of the inferior lobe, and the vertebræ ossified; but in some of the lower and older types both heterocercal tails and notochordal vertebræ still remain. Diphycercal tails also continue well along in the ascending scale.

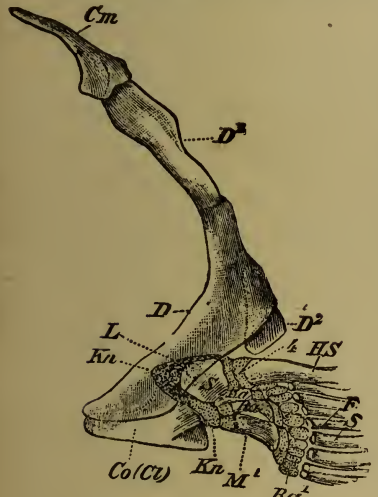


Fig. 9.—*Salmo fario L*; left shoulder-girdle; *Cm*, posttemporal; *D 1*, epiclavicle; *D*, clavicle; *D 2*, postclavicle; *S*, scapula; *Co* (*Cl*), coracoid; *Ra*, basilars; *L*, scapular foramen; *HS*, *FS*, fin-rays.

The Actinopterygia fall into two tribes:

Ventral fins abdominal; a ductus pneumaticus; no spinous dorsal fin; parietal bones not usually separated by supraoccipital; scales usually cycloid; *Malacopteri.*

Ventral fins usually thoracic or jugular; no ductus pneumaticus; usually a spinous dorsal fin; parietal bones usually separated by the supraoccipital; scales usually ctenoid; *Acanthopteri.*

In the cartilaginous fin-rays and posterior ventral fins the Malacopteri most nearly approach the fishes of the superorders considered in the preceding pages, than do the Acanthopteri. The persistence of the communication between the swim-bladder and the gullett (ductus pneumaticus) is another indication of this affinity. Accordingly we find representatives of the Malacopteri in older periods than we do the

Acanthopteri. They are abundant in the Jurassic and Cretaceous and later periods, while the Acanthopteri are very rare first in the Cretaceous, and are abundant first in the Eocene.

The orders of the Malacopteri are the following:

I. Median fins with actinotrichia.

Basilars of median fins well developed; notochord persistent; (1) *Docopteri.**

II. Median fin-rays equal to and articulating with axonosts.

α, Vertebræ complex, the pleurocentra and intercentra distinct.

Anterior vertebræ similar to others; (2) *Merospondyli.*

αα, Vertebræ with centra and intercentra both complete on part of the column at least; amphicœlous;

Anterior vertebræ similar; (3) *Halecomorphi.*

ααα, Vertebræ (intercentra) opisthocœlous.

Anterior vertebræ similar; a precoracoid arch and a coronoid bone; (4) *Ginglymodi.*

αααα, Vertebræ (intercentra) amphicœlous.

β A, Precoracoid arch.

γ, No symplectic bone.

Pterotic simple; anterior vertebræ modified, and with ossicula auditus; parietals not distinct (5) *Nematognathi.*

Pterotic annular, including a cavity which is closed by a distinct bone; anterior vertebræ simple, without ossicula auditus; parietals distinct; (6) *Scyphophori.*

γγ, A symplectic bone.

Anterior vertebræ coössified, and with ossicula auditus; pterotic simple; parietals distinct; (7) *Plectospondyli.*

Anterior vertebræ not modified; pterotic simple; parietals distinct; (8) *Isospondyli.*

β β, No precoracoid arch.

γ, Scapular arch suspended to cranium.

δ, A symplectic.

Anterior vertebræ and pterotic simple; parietals separated by supraoccipital; (9) *Haplomi.*

Anterior vertebræ modified; parietals not separated; (10) *Glanencheli.*

δδ, No symplectic.

Anterior vertebræ simple; a preoperculum and palatine arch; (12) *Ichthyocephali.*

γγ, Scapular arch free from cranium.

δ, A symplectic bone.

Hyoid arches and pectoral baseosts developed; (13) *Holostomi.*

Baseosts fused into a single cartilage; (11) *Xenomi.*

* The position of this order is uncertain.

$\delta\delta$, No symplectic.

Opercular bones and five osseous branchial arches, with ceratohyal; (14) *Enchelycephali.*

Opercular bones and one osseous branchial arch, ceratohyal; (15) *Colocephali.*

No opercular bones, nor ceratohyal, nor osseous branchial arches; (16) *Lyomeri.*

The families of the Physostomi are as follows:

Docopteri; Dorypteridæ.

Merospondyli; Sauropsidæ; Pycnodontidæ; Stylodontidæ; Sphærodontidæ; Macrosemiidæ.

Halecomorphi; Amiidæ (dog-fishes).

Ginglymodi; Lepidosteidæ (bony gars).

Isospondyli; Dapediidæ; Lepidotidæ; Aspidorhynchidæ; Saurodontidæ (Fig. 10); Osteoglossidæ; Heterotidæ; Galaxiidæ; Clupeidæ (herring); Chirocentridæ; Salmonidæ (salmon); Thymallidæ (grayling); Alepocephalidæ; Gonorhynchidæ; Sauridæ; Lutodiridæ; Aulopidæ; Elopidæ; Albulidæ; Hyodontidæ; Notopteridæ.

Actinochiri; Pelecopteridæ.

Plectospondyli; Characinidæ; Sternopygidæ; Cobitidæ; Cyprinidæ (carp); Catostomidæ (suckers).

Scyphophori; Mormyridæ; Gymnarchidæ.

Nematognathi; Siluridæ (cat-fishes); Hypophthalmidæ; Aspredinidæ.

Haplomi; Esocidæ (pike); Stratodontidæ; Umbridæ; Cyprinodontidæ; Amblyopsidæ (blind fishes).

Xenomi; Dalliidæ.

Glanencheli; Gymnotidæ (electric eels).

Ichthyocephali; Monopteridæ.

Holostomi; Amphipnoidæ.

Enchelycephali; Nemichthyidæ; Anguillidæ (eels); Congridæ (eels) Synaphobranchidæ; Simenchelyidæ.

Colocephali; Murænidæ (eels).

Lyomeri; Saccopharyngidæ; Eurypharyngidæ.

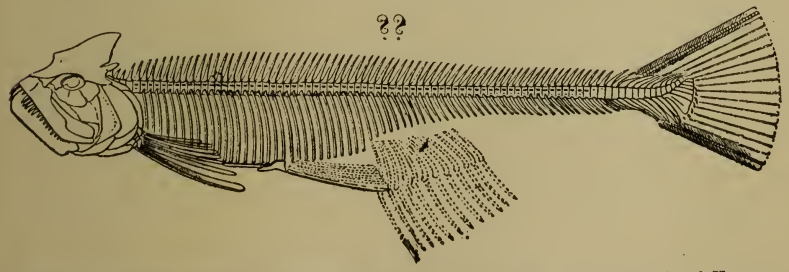
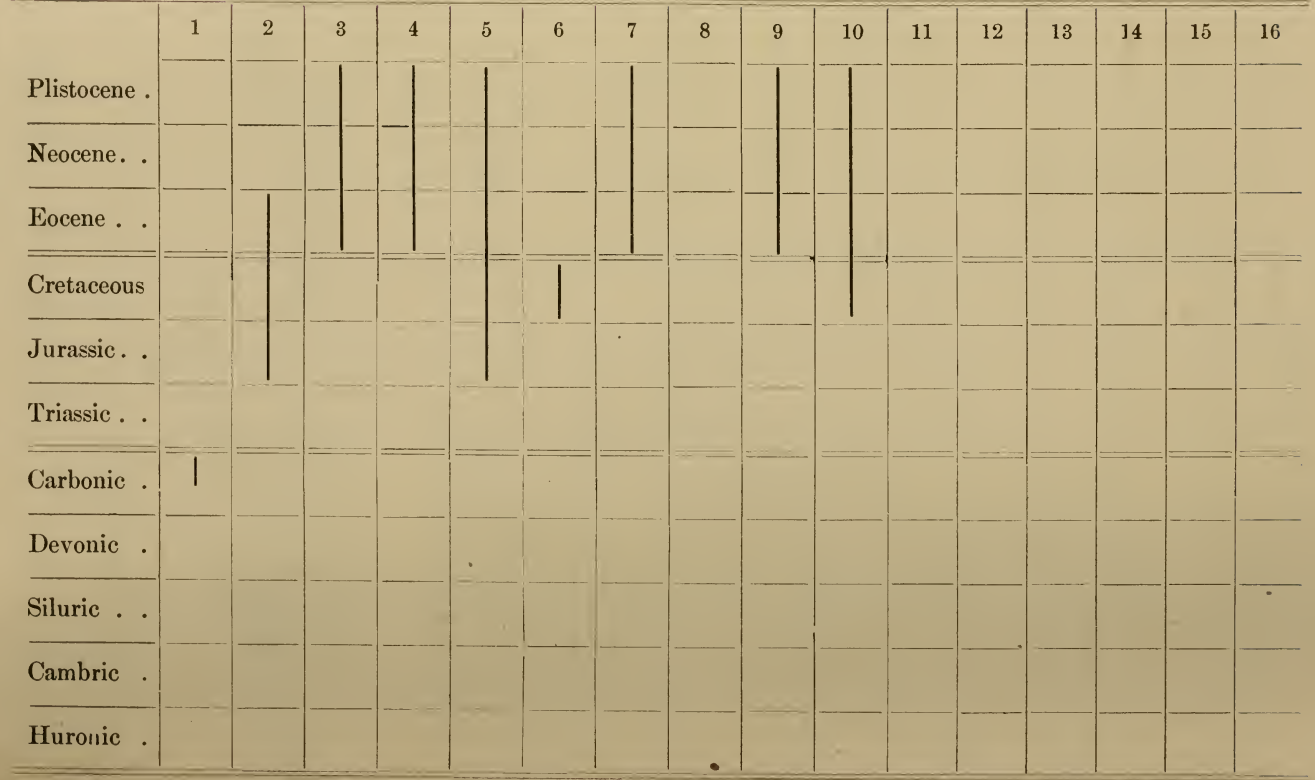


Fig. 10.—*Portheus molossus*, Cope; isospondylous fish from the Upper Cretacic of Kansas, one-twentieth natural size. Original.

The geological range of the orders of the Malacopteri is as follows: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16
Plistocene .
Neocene . .
Eocene . .
Cretaceous
Jurassic . .
Triassic . .
Carbonic .
Devonic .
Siluric . .
Cambric .
Huronic .

The orders of which no record is given are only known in the living state. The Plectospondyli represent the highest form of the Malacopteri, while the Haplomi give the connection with the Acanthopteri through the Percesoces of the latter. The Isospondyli offer the connection with the Merospondyli. The Apodal line (the eels), including orders Nos. 12 to 15, is a degenerate one, ending in the greatly degenerate deep-sea forms of the Lyomeri.

The orders of the Acanthopteri are the following:

A. Scapular arch suspended posterior to the cranium.

Maxillary bone distinct; no interclavicles; epibranchials and pharyngeals present; inferior elements distinct; (1) *Opisthomi.*

AA. Scapular arch suspended to cranium by a posttemporal bone.

a, Ventral fins abdominal.

Branchial arches developed, third superior pharyngeal enlarged; gill-fringes linear; no interclavicles; (2) *Percesoces.*

Epibranchials and superior pharyngeals reduced in number; interclavicles; gill-fringes linear; (3) *Hemibranchii.*

Epibranchials and superior pharyngeals wanting; gill-fringes in tufts; (4) *Lophobranchii.*

aa, Ventral fins thoracic or jugular.

β, Anterior (spinous) dorsal fin expanded into transverse laminæ, sessile on cranium.

Cranium normal; branchial bones present; (5) *Discocephali.*

β,β, Spinous dorsal fin not tranversely expanded.

γ, Posttemporal projecting freely from skull.

First vertebra united by suture to cranium; intercalaria united behind supraoccipital; basilar pectoral bones elongated; (6) *Pediculati.*

Posterior cephalic region normal; the anterior twisted so as to bring both orbits on one side; inferior pharyngeals distinct; (7) *Heterosomata.*

Cranium normal, premaxillaries usually coössified with maxillaries behind, and the dentary with the articular; pharyngeal bones distinct; (8) *Plectognathi.*

Cranium normal; bones of jaw distinct; (9) *Percomorphi.*

γγ. Posttemporal an integral part of the skull.

Cranium normal; bones of jaws distinct; pharyngeals separate; (10) *Craniomi.*

The families of the preceding orders are as follows:

Opisthomi; Mastacembelidæ; Notacanthidæ.

Percesoces; Opheocephalidæ; Mugilidæ (mullets); Atherinidæ; Sphyrænidæ (barracuda); Scombresocidæ (soft gar).

Hemibranchii; Pegasidæ; Gasterosteidæ (stickle-back); Fistulariidæ; Centriscidæ; Amphisilidæ; Dercetidæ.

Lophobranchii; Solenostomidæ; Syngnathidæ (pipe-fishes); Hippocampidæ (sea-horses).
Discocephali; Echeneididæ (remoras).
Pediculati; Antennariidæ; Lophiidæ (fishing frog).
Heterosomata; Pleuronectidæ (flat-fishes).
Plectognathi; Triacanthidæ; Balistidæ (trigger-fishes); Tetrodontidæ (bladder-fishes); Diodontidæ; Ostraciidæ.
Percomorphi; (Anacanthini) Ophidiidæ; Gadidæ (cod); Macruridæ; (Haplodoci) Batrachidæ (toad-fishes); (Cyclopteroidea) Cyclopteridæ; (Scatophagoidea) Scatophagidæ; (Epilasmia) Acroneuridæ; Chætodontidæ; (Rhegnopteri) Trichidiontidæ; (Distegi) Scorpænidæ; Cottidæ (sculpins); Blenniidæ; Gobiidæ; Platycephalidæ; Rhamphocottidæ; Agonidæ; Heterognathidæ; Gerreidæ; Carangidæ (pompano); Sillaginidæ; Pristipomatidæ; Scienidæ (maigres); Sparidæ; Percidæ (perch); Berycidæ; Scombridæ (mackerel); Trichiuridæ; Xiphiadidæ; (Labyrinthici) Osphromenidæ; Anabantidæ; (Pharyngognathi) Embiotocidæ; Cichlidæ; Labridæ; Scaridæ.
Craniomi; Triglidæ (gurnards); Dactylopteridæ.

The table shows that no order of the Acanthopteri has become extinct. The Percomorphi display the greatest numbers and importance at the present time. The Lophobranchii and Plectognathi are degenerate types.

The geological distribution of these orders is as follows:

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Plistocene . . . .
Neocene . . . . .
Eocene . . . . .
Cretacic . . . . .
Jurassic . . . . .
Triassic . . . . .
Carbonic . . . . .
Devonic . . . . .
Siluric . . . . . .
Cambric . . . . .
Huronic . . . . .

Class III.—BATRACHIA.

There are three subclasses of Batrachia, as follows:

Basioccipital, supraoccipital, intercalary, and supratemporal bones present; propodial bones distinct; *Stegocephali.*

Basioccipital, supraoccipital, and supratemporal bones wanting; propodial bones distinct; no urostyle; *Urodela.*

Basioccipital, supraoccipital, intercalare, and supratemporals wanting; frontals and parietals connate; propodial bones connate; lumbosacral vertebræ united into a urostyle; *Salientia.*

Subclass I.—STEGOCEPHALI.

There are four orders of Stegocephali.

a, One occipital cotyloid articulation.

Vertebral bodies represented by basal and lateral elements (intercentra and centra); *Ganocephali.*

aa, Two occipital condyles.

Vertebræ represented by distinct and incomplete intercentra and centra (pleurocentra); atlas segmented; *Rhachitomi.*

Centra and intercentra complete, making two vertebral bodies to each neural arch; *Embolomeri.*

No centra; intercentra, each supporting a neural arch; *Microsauri.*

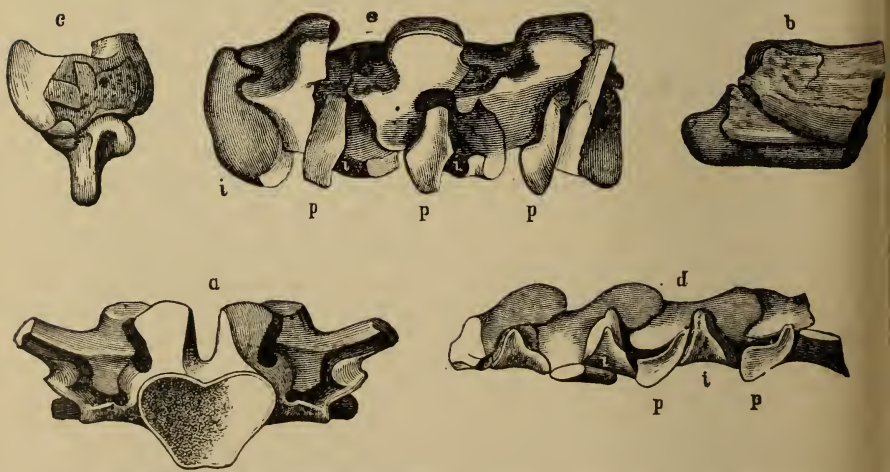


FIG. 11.—*Trimerorhachis insignis* Cope; parts of skeleton, natural size; *a*, occipitalsegment with single cotylus; *b*, *c*, posterior part of lower jaw; *d*, *e*, series of vertebræ; *d*, side view, depressed; *e*, view obliquely from above, both showing the rhachitomous structure; *i*, intercentra; *p*, pleurocentra. Original. From the Permian of Texas.

The Stegocephali are only known from the Carbonic and Triassic systems. They are all more or less notochordal, but a considerable range in this respect is found in the Microsauri. In some of them the notochord is cut off by the vertebral ossification, while in others (Branchiosaurus) the ossification is a mere sheath round the chorda. In the Ganocephali and Rhachitomi the vertebral centra are represented by a segment beneath each branch of the neural arch, the pleurocentrum (Fig. 11, *p*); and these rest below on a median inferior piece, the intercentrum (Fig. 11, *i*). In the Embolomeri each of these segments is developed so as to form a disc, so that there are two vertebral bodies to one arch. In the Microsauri the intercentra have been fused with the pleurocentra, so that the body consists principally of the

FIG. 12.—*Trimerorhachis insignis* Cope; skull. From the Permian bed of Texas. Original.

former, and the same structure is characteristic of the remaining Batrachia. In the Reptilia, on the other hand, the intercentra gradually disappear, being represented in most of the types in the cervical and caudal regions only. In the latter they support the chevron bones.

Of the GANOCEPHALI two families are known, the Trimerorhachidæ (Figs. 11–12), without, and the Archegosauridæ with neural spines of the vertebræ. They occur in the Coal Measures and the Permian of Europe and North America.

The RACHITOMI possesses but one family, the Eryopidæ, which often reached a large size (Fig. 13). These are confined to the Coal Measures.

If the Labyrinthodontidæ belong to this order they range also to the Trias inclusive, in both continents.

The EMBOLOMERI includes one family, the Cricotidæ, which belongs to the Permian of Europe and North America. (Fig. 14.)

The MICROSAURI embraces the following families: Branchiosauridæ; Hylonomidæ; Molgophidæ; Phlegthontiidæ. The smaller forms are mostly from the Coal Measures, while some large ones occur in the Trias. Some of the Hylonomidæ come from the Permian of North America and Europe. They were mostly of small size, and their ver-

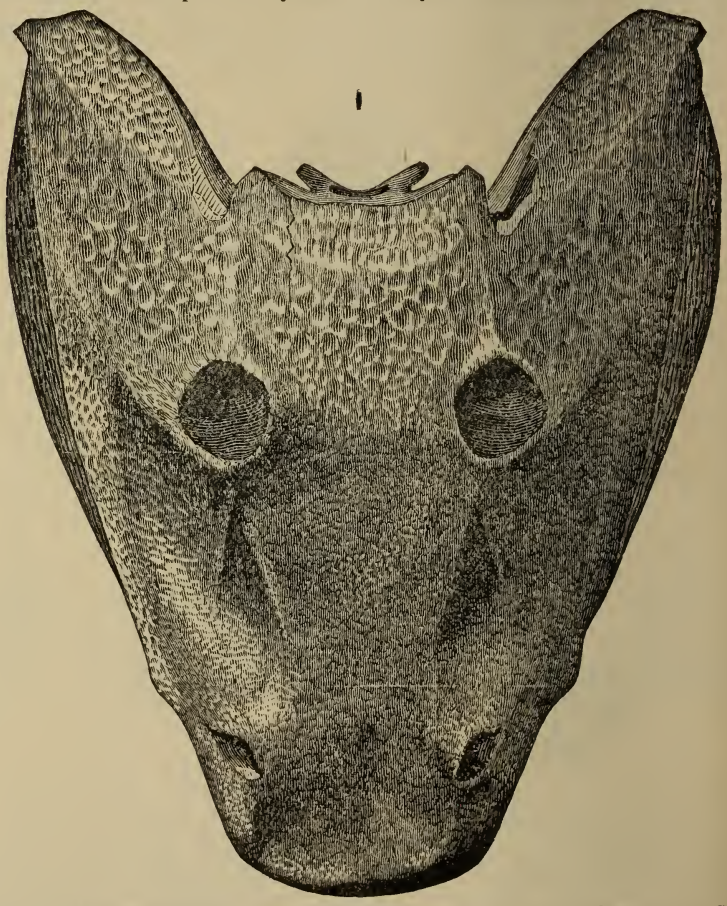


FIG. 13.—*Eryops megacephalus* Cope; skull, from above, one-fourth natural size. From Permian bed of Texas. From Cope.

tebræ exhibit very various degrees of ossification. In some the bodies are completely ossified, while in others the ossification forms a superficial layer. In the Labyrinthodontidæ the ossification is more complete. The dentine may be entire, or deeply inflected, so as to form straight or labyrinthic folds.

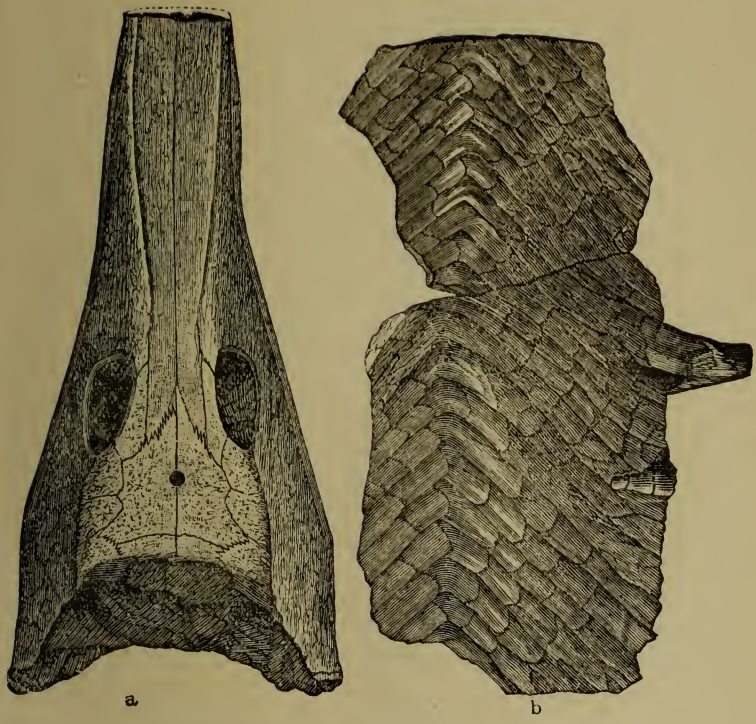


FIG. 14.—*Cricotus heteroclitus* Cope; one-third natural size. From Permian of Texas. *a*, head from above; *b*, part of belly from below. From Cope.

Subclass II.—URODELA.

There are three orders of Urodela.

a, An os intercalare.
Palatine arch and vomer present; *Proteida.*

aa, No os intercalare.
A maxillary arch and vomers; *Pseudosauria.*
No maxillary arch or vomers; *Trachystomata.*

Under the PROTEIDA the only family known is the Proteïdæ (Fig. 15).

The PSEUDOSAURIA embraces the following families: Cryptobranchidæ; Amblystomidæ; Hynobiidæ; Plethodontidæ; Thoriidæ; Desmognathidæ; Salamandridæ; Pleurodelidæ; Amphiumidæ; Caeciliidiæ.

The TRACHYSTOMATA includes only the family of the Sirenidæ.

A possible member of the Proteida occurs in the Coal Measures, but certainly known members of the order are not known in a fossil state. Of Pseudosauria fossil forms are first found in the Laramie in America, and they are not uncommon in the Neocene in Europe. Trachystomata are not known fossil.

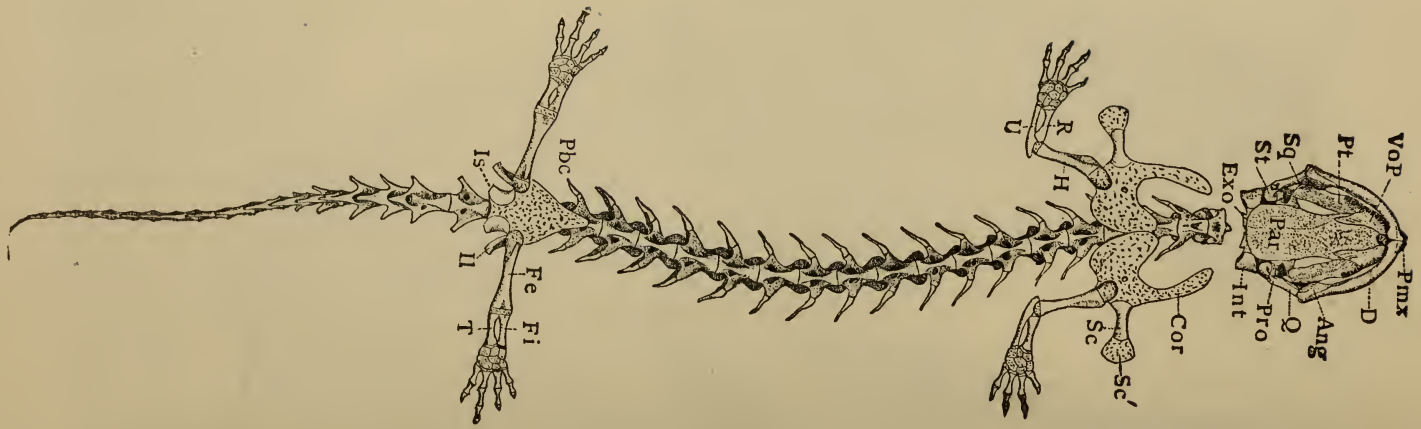


Fig. 15.—*Necturus maculatus* Raf.; skeleton, from below, two-thirds natural size; *Pmx*, premaxillary bone; *Vop*, vomeropalatine; *Pt*, pterygoid; *Sq*, squamosal; *Q*, quadrate; *Pro*, proötic; *Int*, intercalare; *St*, stapes; *Exo*, exoccipital; *Par*, parasphenoid; *Ang*, angular; *D*, dentary; *Cor*, Coracoid; *Sc*, scapula; *H*, humerus; *R*, radius; *U*, ulna; *Pbc*, pubic cartilage; *Fe*, femur; *Fi*, fibula; *T*, tibia; *Il*, ilium; *Is*, ischium.

Subclass III.—SALIENTIA.

But one order of this subclass is recognized. It is thus defined:

Vomers and palatopterygoid arch present; *Anura.*

The ANURA has the families arranged under the following suborders:

Internal nostrils opening together on the middle line; no tongue; coracoids connected by a cartilage on each side; *Aglossa.*

Internal nostrils separate; a tongue; coracoids connected by a separate cartilage on each side, one overlapping the other; *Arcifera.*

Internal nostrils separate; a tongue; a single median cartilage connecting all the coracoids; scapular arch free; *Firmisternia.*

As in Firmisternia, but scapular arch articulated to skull; *Gastrechmia.*

(Aglossa): Xenopidæ; Pipidæ.

(Arcifera): Discoglossidæ; Bufonidæ; Dendrophryniscidæ; Asterophrydidæ; Pelodytidæ; Scaphiopidæ; Hylidæ; Cystignathidæ; Amphignathodontidæ; Hemiphractidæ.

(Gastrechmia): Hemisidæ.

(Firmisternia): Engystomidæ; Phryniscidæ; Dendrobatidæ; Cophylidæ; Dyscophidæ; Colostethidæ; Ranidæ; Ceratobatrachidæ.

Remains of Anura have been found in the Jurassic beds of Colorado, but to which suborder they pertain is unknown. They next appear in the Eocene of Wyoming. Well-defined forms are found in the phosphorites of France, which include both Arcifera and Firmisternia. They continue to the present day.

The time relations of the orders of Batrachia are represented in the preceeding table.

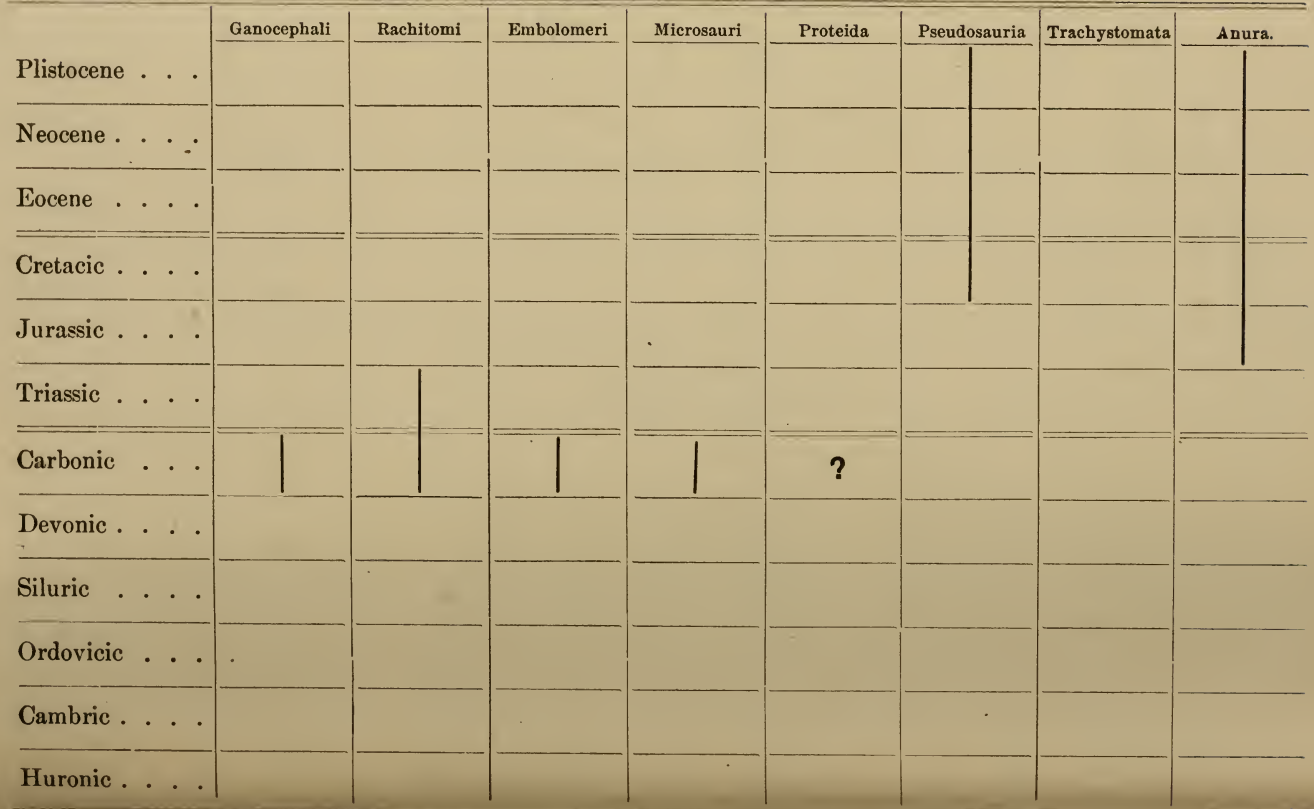
Class IV.—MONOCONDYLIA.

There are two subclasses of Monocondylia.

Anterior limbs ambulatory, with numerous carpal and metacarpal bones; two aorta roots; integument consisting partly of scales; *Reptilia.*

Anterior limbs volant, with the carpals and metacarpals more or less coössified and reduced in numbers; integument consisting in part of feathers; one aorta root; *Aves.*

Approximations between these subclasses exist at various points. Thus the Dinosaurian reptiles resemble birds in the structure of the posterior limbs and pelvis; while among birds the Saururæ approach reptiles in the structure of the manus and of the caudal vertebræ. The definitions above given are, however, not violated.


Ganocephali
Rachitomi
Embolomeri
Microsauri
Proteida
Pseudosauria
Trachystomata
Anura.
Plistocene . . .
Neocene . . . .
Eocene . . . .
Cretacic . . . .
Jurassic . . . .
Triassic . . . .
Carbonic . . .
Devonic . . . .
Siluric . . . .
Ordovicic . . .
Cambric . . . .
Huronic . . . .
?

Subclass I.—REPTILIA.

Nine orders of Reptilia are known.

I. The quadrate bone united with the postorbital bars by suture.

A. Cranium with one postorbital bar. (Synaptosauria.)

a, A paroccipital bone.

A supratemporal bone; ribs two-headed on centrum; carpals and tarsals not distinct in form from metapodials; (1) *Ichthyopterygia.*

No supratemporal; sub- and postpelvic ossifications; interclavicle and clavicles separated from and below scapular arch; ribs one-headed; coracoid large, free; (2) *Testudinata.*

aa, No paroccipital bone.

Ribs mostly two-headed, capitulum intercentral; clavicles and interclavicles forming part of shoulder girdle; no sub- or postpelvic bones; pelvic elements below plate-like; obturator foramen small or none; (3) *Theromora.*

Ribs one-headed; scapula triradiate; no clavicles; coracoid large, distinct; no sub- or postpelvic bones; (4) *Plesiosauria.*

AA. Cranium with two postorbital bars. (Archosauria.)

a, No paroccipital bone; (no supratemporal).

Ribs two-headed; no interclavicle; external digits greatly elongate to support a patagium; (5) *Ornithosauria.*

Ribs two-headed; no interclavicle; acetabulum perforate; feet ambulatory; no patagium; (6) *Dinosauria.*

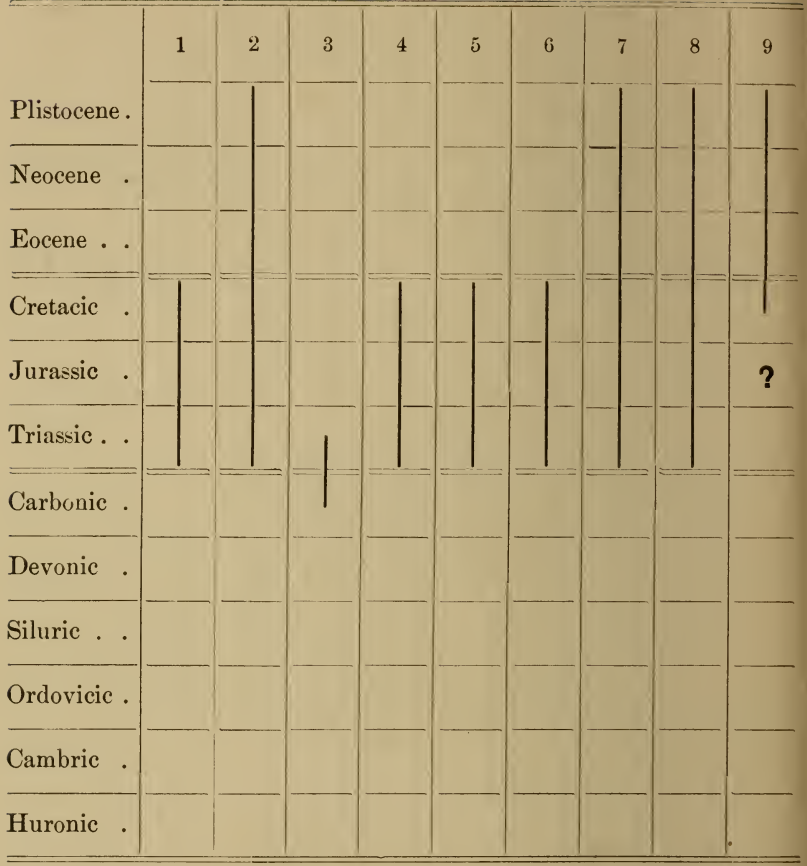
Ribs two-headed; an interclavicle; acetabulum closed; feet ambulatory; no postfrontal bone; (7) *Crocodilia.*

Ribs one-headed; an interclavicle; acetabulum closed; feet ambulatory; (8) *Rhynchocephalia.*

II. The quadrate bone loosely articulated with the postorbital bars and only proximally. (Streptostylica.)

The quadrate bone in contact only with adjacent elements; no paroccipital; supratemporal present; ribs one-headed; one or no postorbital bar; (9) *Squamata.*

The geological relations of these orders are as follows:



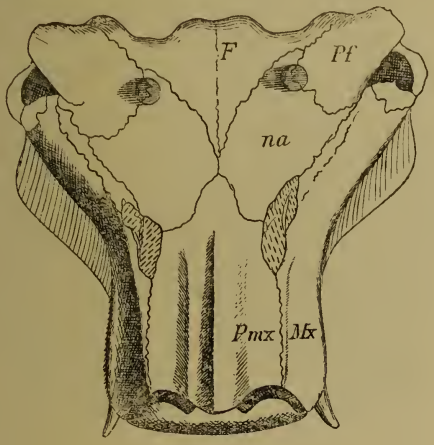
The above table shows that the Theromora is the only Paleozoic order. Its members appeared towards the close of the Carbonic system, and spread over the whole earth before the end of the Paleozoic ages. Their remains have been found in New Mexico, Texas, Illinois, France, Germany, Russia, and the Cape Colony of Africa. They include carnivorous forms and those with a molar dentition for crushing hard substances (Fig. 17). They display some points of strong resemblance to the Mammalia. Thus in the Theriodontia the posterior foot is closely similar to that of the Monotrematous order. In several families the humerus strongly resembles that of the same type. The scapular arch in the Procolophonina resembles that of the same type. In the Theriodontia the coracoid bone is reduced as in the salamanders. In the Diadectidæ there are teeth on the vomer as in the same. The humeral condyles are much like those of salamanders. The vertebræ are biconcave and mostly notochordal, in all Theromora, thus resembling the Batrachia. Thus the Theromora are at once more nearly allied to

the Batrachia on the one hand and the Mammalia on the other than any other reptiles. The size of the known species ranges from that of a rat up to that of a lion.

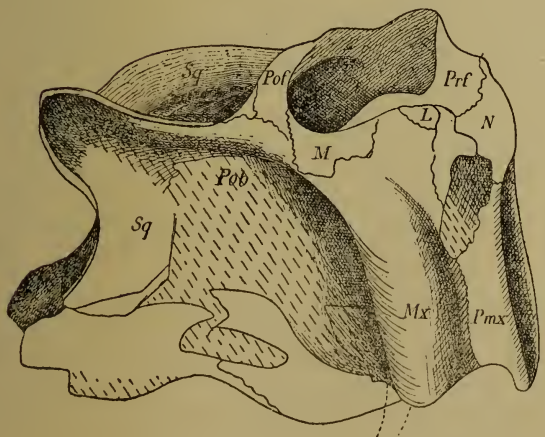
The order THEROMORA includes five suborders.

I. Palate closed, except posteriorly.
A temporal foramen; *Placodonta.*

II. Palate open anteriorly for nares.
A. The coracoid bone large, reaching sternum.
Dentition abundant; pubis and ischium plate-like; ribs one-headed; *Proganosauria.*



a



b

FIG. 16.—*Lystrosaurus frontosus* Cope; an Anomodont from South Africa, one-third natural size.

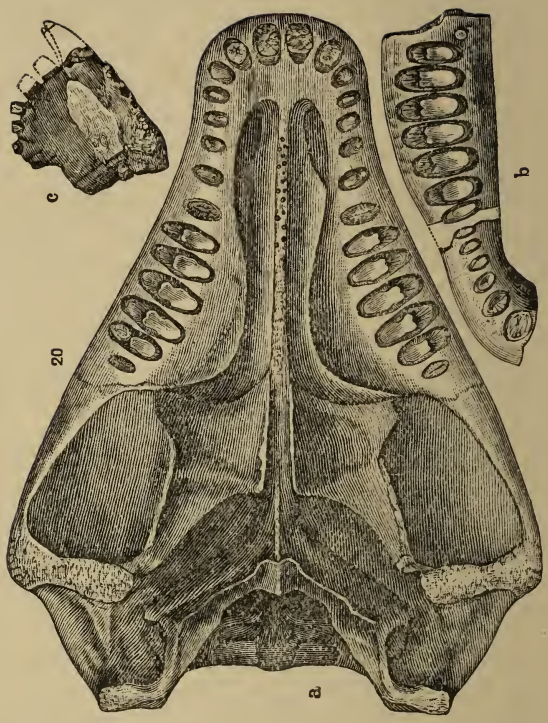


FIG. 17.—*Empedias molaris* Cope; inferior view of skull, one-third natural size. A Cotylosaurian from the Permian of Texas.

Four or five sacral vertebræ; centra not notochordal; no intercentra; dentition imperfect or wanting; obturator foramen minute; *Anomodonta.*

AA. The coracoid reduced, not reaching sternum.

Ribs two-headed; two or or three sacral vertebræ; centra generally notochordal; intercentra generally present; dentition abundant; *Theriodonta.*

Ribs single-headed; temporal fossa overroofed; dentition abundant; intercentra; *Cotylosauria.*

The *Placodonta* includes the Placodontidæ only. The *Proganosauria*, the Mesosauridæ, the Procolophonidæ, Proterosauridæ, and Rhynchosauridæ. *Cotylosauria* includes the Pariasauridæ and the Diadectidæ (Fig. 17).

The *Theriodonta* embraces the families of the Clepsydropidæ, Pariotichidæ, and Bolosauridæ. The *Anomodontia* includes the single family of the Dicynodontidæ (Fig. 16), and perhaps the Endothiodontidæ.

The geographical distribution of these suborders is as follows:

	N. America.	S. America.	Europe.	Africa.
Placodontia;			×	
Proganosauria;		×	×	×
Anomodontia;			×	×
Theriodonta;	×		×	×
Cotylosauria;	×		×	×

Of the above families the Placodontidæ and the Proterosauria occur in the the Trias. The others are confined to the Permian.

The PLESIOSAURIA embraces the following families: Plesiosauridæ, Nothosauridæ, and Lariosauridæ. The last two families are only known from the Triassic of Europe. The Plesiosauridæ range from the Jurassic to the Cretaceous, inclusive, and include many species. They are all adapted for aquatic life, and were sometimes formed like the Cetacea; but others had very long necks, which could extend the head to great depths or reach the surface when the body was sunk. Some of the species reached a length of forty or fifty feet. Their remains have been found in North and South America, Europe, and New Zealand.

The order TESTUDINATA presents four subordinal modifications, as follows:

I. No descending processes of the parietal bones.
Vertebræ and ribs free and separated from a bony exoskeleton; no descending processes of the parietals; *Athecæ.*

II. A carapace and plastron, and descending process of parietals.
a, Sacral and caudal ribs articulating with neural arches only.
Neck bending in vertical plane, last cervical articulating with first dorsal by zygapophyses only; pelvis not anchylosed; marginal bones wanting or rudimental; *Trionychoidea.*

aa, Sacral and caudal ribs articulating with body of vertebræ only.
As the last; but marginal bones present and connected with ribs, and last cervical and last dorsal vertebræ articulating by bodies; pelvis not anchylosed to plastron; *Cryptodira.*
Neck bending in horizontal plane, the last cervical and first dorsal vertebæ articulating by bodies; pelvis anchylosed to carapace and plastron; marginal bones present and connected with ribs; *Pleurodira.*

The *Athecæ* includes the single family of the Dermochelydæ.

The *Trionychoidea* includes only the Trionychidæ.

The *Cryptodira* embraces the Cheloniidæ, Testudinidæ (Fig. 18), Cinosternidæ, Dermatemydidæ, Chelydridæ, Baënidæ, and Adocidæ.

The *Pleurodira* includes the Pleurosternidæ, Sternothæridæ, Pelomedusidæ, Pleisiochelydidæ, Chelydidæ, and Carettochelydidæ.

The earlier tortoises are intermediate in character between the Cryptodira and Pleurodira, and they have continued side by side to the

present day. The Pleurodira are, however, now confined to the Southern Hemisphere. The Trionychoidea first appear in the Cretaceus, and continue as the so-called soft-shelled turtles of fresh water.

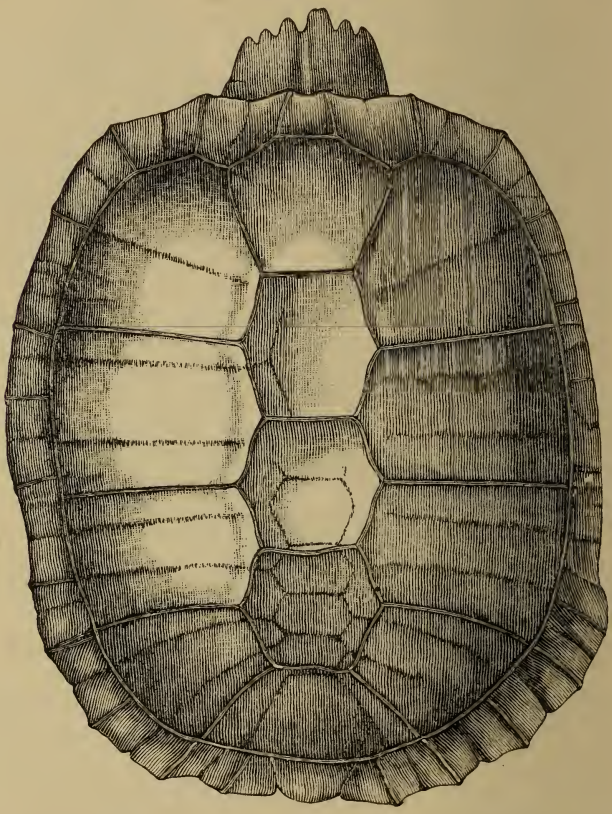


FIG. 18.—*Testudo laticuneus* Cope; carapace, from above, one-fourth natural size. From the White River Neocene bed of Nebraska.

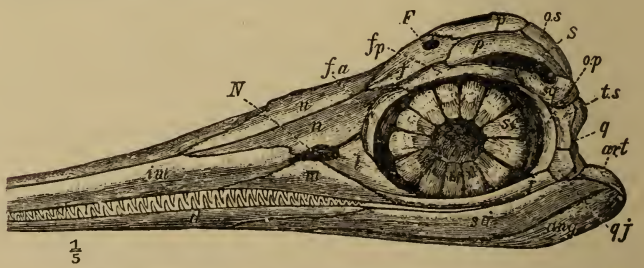


FIG. 19.—*Ichthyosaurus tenuirostis* Conyb.; one-sixth natural size. From the Lias of Würtemburg. From Doederlein.

The Athecæ first appear in the Eocene, and were then and still are marine in their habits; but one species now exists, the "leather-back turtle."

The order Ichthyopterygia embraces the families of Ichthyosauridæ and Mixosauridæ. The Mixosauridæ have the bones of the fore arm and leg distinguished by their form from those of the carpus and tarsus, and they thus approach more nearly other reptiles. They are the oldest family inhabiting the European waters during the period of the Trias. In the Ichthyosauridæ all the bones of the limbs have the same form, except the humerus and femur. They continued until the close of the Cretaceous. They were the especially marine Reptilia, having the shape and habits of the Cetacea. They reached the length of twenty-five feet during the Cretaceous period. Their remains have been found in all parts of the world except Africa, but they were more numerous in the oceans now covered by Europe than elsewhere. Some of the forms had but few (Muræosaurus) and others (Baptanodon) no teeth. This typical genera had numerous teeth grooved at the base. The vertebræ are short and biconcave (Fig. 19).

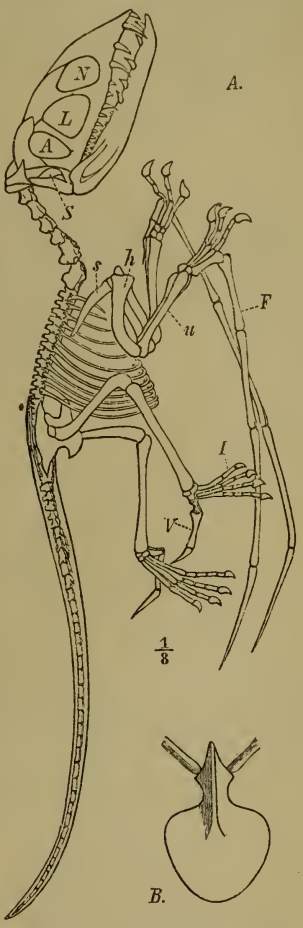


Fig. 20.—*Dimorphoda macronyx* Ow. from the English Trias. *B*, sternum. From Owen.

Two families enter the Ornithosauria, viz., the Pteranodontidæ and the Pterodactylidæ. The last-named family is furnished with teeth, while the first-named includes species which have a toothless beak like that of abird. The Pterodactylidæ range from the Trias to the Cretaceous inclusive. The earlier forms had a long tail, and these continued through the Jurassic (Fig. 20). Some of the later forms had an edentulous beak in front of the toothless portion. The true Pterodactyles had a much abbreviated tail and a long neck.

The Ornithosauria were the flying order of reptiles, comparing with the other orders much as bats compare with other orders of Mammalia.

The Dinosauria include the great land reptiles of the Mesozoic systems. The order embraces no species adapted for flight, and none adapted for a life in which movement was made by paddles or limbs modified for swimming. The order includes the largest land animals

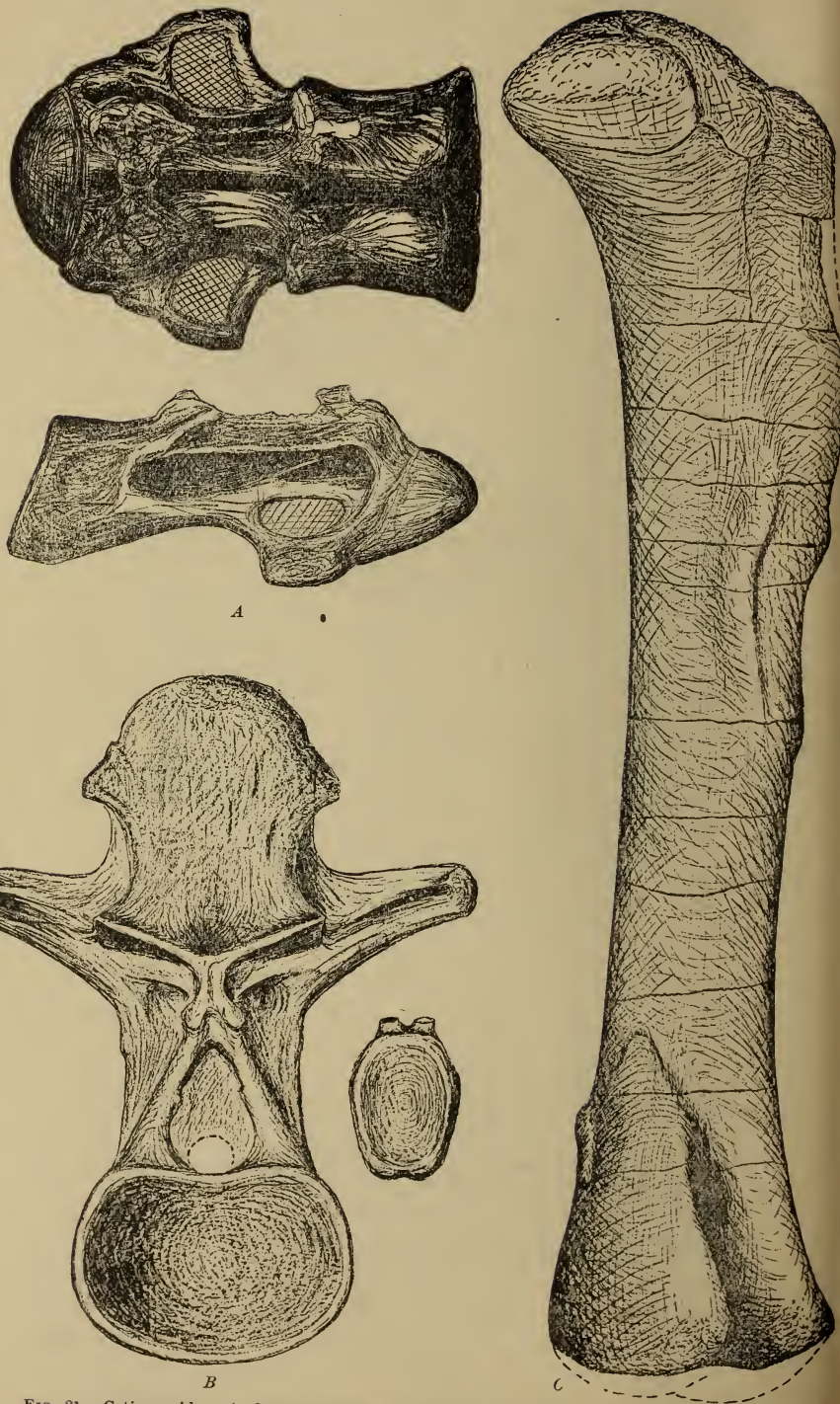


FIG. 21.—Cetiosauridæ; *A*, *Camarasaurus supremus* Cope; cervical vertebra, from above and side, one-tenth natural size; *B*, do, dorsal vertebra, from behind, one-tenth natural size; *C*, *Amphicœlias altus* Cope; femur, from behind, one-tenth natural size.

that have ever lived, and their remains have been found in all except the Australian continents.

The Dinosauria embrace two suborders, as follows:

Pubic elements directed downwards;	*Saurischia.*
Pubic elements directed backwards;	*Orthopoda.*

The Saurischia were mostly of carnivorous habits, while the Orthopoda were herbivorous. Both suborders commence in the Trias, and close with the end of the Postcretaceous. To the Saurischia belong two families, the Cetiosauridæ and the Megalosauridæ, the former supposed to be herbivorous, the latter carnivorous. The former have robust inferior pelvic bones, and teeth with spoon-shaped crowns. The latter have long, slender pubis and ischium, and sharp, knife-shaped teeth. To the Cetiosauridæ belong the largest known Vertebrata with ambulatory legs; the *Camarasaurus supremus* Cope measuring seventy feet in length, and the *Amphicœlias fragilissimus* Cope being considerably larger. These creatures had the dorsal vertebræ hollow, and probably penetrated in life by branches from the lungs, while the tail vertebræ and limb bones are solid. The former served as floats and the latter as anchors as they walked on the sea bottom. This family is only known from the Jurassic of Europe and North America (Fig. 21). The Megalosauridæ ranged throughout all Mesozoic time. Some of the species were quite small, and others were gigantic, being the most dangerous carnivorous animals that ever existed. Many of them were of kangaroo-like form, and in some of them the vertebræ were mere hollow shells. In most of them the limb bones were hollow.

The Orthopoda include the Scelidosauridæ, Hypsirhophidæ, Agathaumidæ, Camptosauridæ, Iguanodontidæ, and Hadrosauridæ, all supposed to have been of herbivorous habits. Representatives of these families have been found in both Europe and North America, excepting the Scelidosauridæ, the members of which are so far only known from Europe. They all include large forms, but the most gigantic are members of the last four families. These had an additional bone, the predental, which formed a toothless extremity of the lower jaw, while the Agathaumidæ add a corresponding toothless bone in front of the premaxillary. In all the families except the Agathaumidæ the successional teeth appear on the inner side of the base of the functional teeth, as in lizards. In the Agathaumidæ they appeared under the middle of the base, as in crocodiles. In all except Hadrosauridæ one row was in functional use at a time; but in Hadrosauridæ two or three rows were used at once. Some of the species of the latter had as many as 2,000 teeth arranged in four magazines, one in each jaw (Fig. 22). The Agathaumidæ mostly had formidable horns on the head. In Agathaumas Cope the longest horn was at the middle of the nose; in Polyonax Cope the horns were over the eyes. *Agathaumas sylvestre* Cope reached a length of forty feet, and had the legs of subequal length. Many of the Hadrosauridæ were of kangaroo-like proportions.

FIG. 22.—*Diclonius mirabilis* Leidy; skull, one-seventh natural size. From Cope. *A*, from side; *B*, from below. From the Laramie bed of Dakota.

The CROCODILIA includes three suborders, as follows:

Posterior nostrils opening in front of palate; nasals very short; premaxillary very large; external nostrils posterior, nasals short; *Parasuchia.*

Nasal bones very long, separating the small premaxillaries; external nostrils anterior; *Pseudosuchia.**

Nareal canal underroofed to behind larynx; no clavicle; pubis excluded from acetabulum; external nostrils anterior; *Eusuchia.*

The Parasuchia and Pseudosuchia are restricted to the Trias of both continents. The most important family of the Parasuchia is the Belodontidæ (Fig. 23). The Pseudosuchia include the Aëtosauridæ, the members of which were completely incased in an armor of bony plates. To the Eusuchia belong the true crocodiles. They commence in the Jurassic with the Teleosauridæ and Goniopholididæ, which are followed in the Cretaceous by the Crocodilidæ and Gavialidæ, which still exist (Fig. 24).

The RHYNCHOCEPHALIA include two suborders:

Vertebræ amphicœlous; axis undivided; *Sphenodontina.*

Vertebræ amphiplatyan; dentatum of axis separate; *Choristodera.*

To the Sphenodontina belong the Protorosauridæ and Paleohatteriidæ, from the European Trias, the Homœosauridæ, from the European Jurassic, and the Sphenodontidæ, which are represented by one species now living in New Zealand. They are all of terrestrial habit, and of small or medium size. The only family of the Choristodera is that of the Champsosauridæ, which is found in the Postcretaceous of North America and the Eocene of Europe. The species were aquatic, and reached the size of some of the modern caymans. The dentine is inflected at the base of the teeth, and the limbs were paddle-like. This order furnishes the starting point for the great Archosaurian series.

The SQUAMATA is an extended group, which is represented by three suborders, which are defined as follows:

Alisphenoid modified as epipterygoid or wanting, leaving brain-case open; parietals flat; an interclavicle and clavicle; teeth with dentinal roots: *Lacertilia.*

Epipterygoid present; parietals decurved, partially enclosing brain-case; no clavicle nor interclavicle; teeth with osseous roots; *Pythonomorpha.*

No epipterygoid; brain-case enclosed in front; no clavicle nor interclavicle; no fore limbs; teeth rootless; *Ophidia.*

The three suborders of Squamata first appear in the Cretacic system. The Lacertilia and Ophidia still exist, but the Pythonomorpha did not survive Mesozoic time.

* Position as yet doubtful.

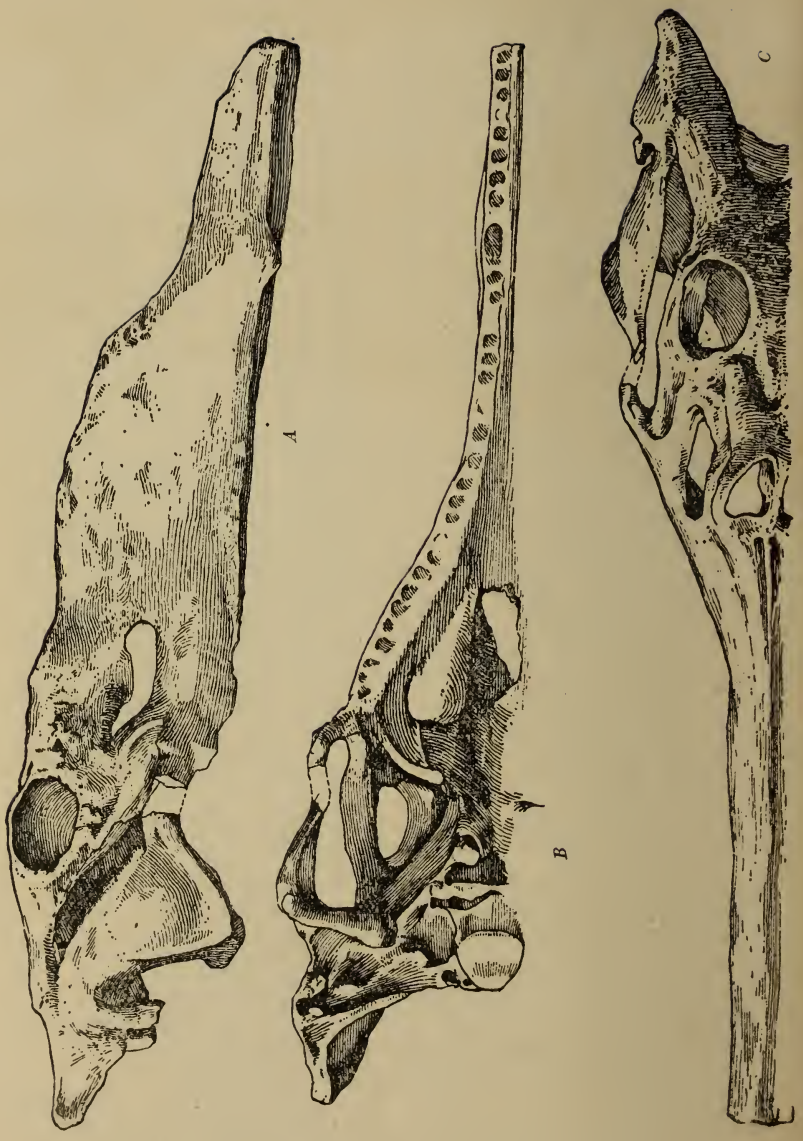


FIG. 23.—*Belodon buceros* Cope; skull, one-fourth natural size. From the Trias of the Rocky Mountains. *A*, the side; *B*, below; *C*, above. Original.

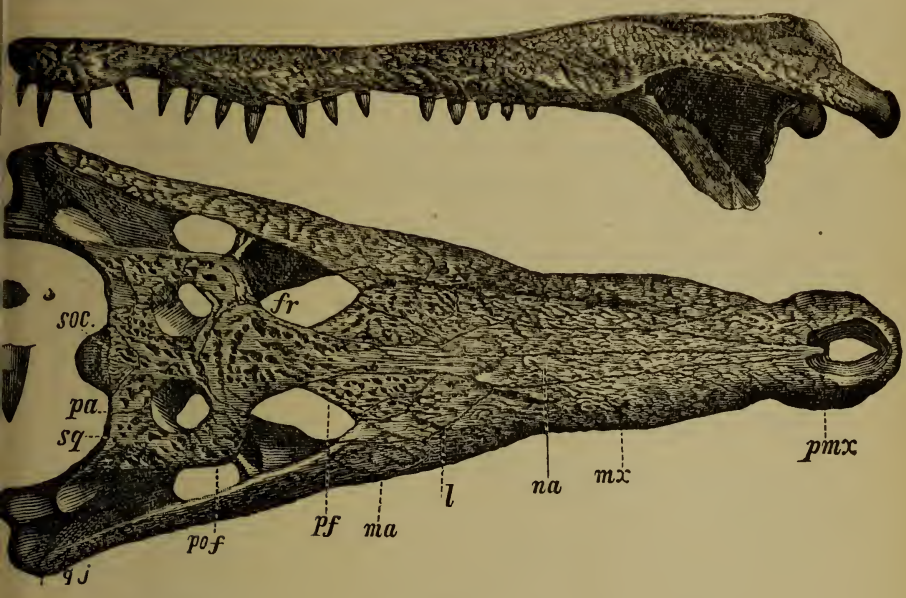


FIG. 24.—*Crocodilus acer* Cope; skull, one-third natural size. From the Eocene of Utah. Original.

The LACERTILIA embraces the following superfamilies:

I. Cervical vertebræ very numerous, more than nine.
Teeth pleurodont; (1) *Dolichosauria.*

II. Proötic not produced beyond arched body; teeth acrodont; olfactory lobes not underarched; two suspensoria.
No clavicle nor interclavicle; no columella; tongue papillose, its extremity sheathed; (2) *Rhiptoglossa.*
A clavicle proximally simple; an anchor-shaped interclavicle; a columella; tongue papillose, not sheathed; (3) *Acrodonta.*

III. Proötic bone not produced beyond arched body; dentition pleurodont; olfactory lobes not underarched; two suspensoria.
A clavicle proximally simple; an anchor-shaped interclavicle; a columella; tongue papillose, not sheathed; (4) *Iguania.*

IV. Proötic bone not produced beyond arched body; dentition pleurodont, or nearly so; two suspensoria.
a, Clavicle simple proximally; olfactory lobes not underarched by frontal.
Interclavicle cruciform; tongue papillose, (5) *Diploglossa.*
aa, Clavicle proximally simple; olfactory lobes underarched by frontal.
Vertebræ procœlous; tongue smooth; (6) *Thecaglossa.*

Vertebræ amphicœlous; tongue papillose; (7) *Uroplatoidea.*

aaa, Clavicle proximally expanded; olfactory lobes underarched by os frontale.

Tongue papillose or smooth; (8) *Nyctisaura.*

aaaa, Clavicles, when present, expanded proximally; olfactory lobes not underarched.

Vertebræ procœlous; tongue scaly; (9) *Leptoglossa.*

V. Proötic bone produced beyond asched body; one suspensorium (= supratemporal, wanting); pelvic arch rudimentary or wanting.

Frontal bone underarching olfactory lobes; supra-occipital gomphosis internal; no orbitsphenoid; (10) *Anielloidea.*

Frontal bone underarching olfactory lobes; supra-occipital gomphosis external; an orbitsphenoid; (11) *Opheosauri.*

The families of these superfamilies are the following:

Dolichosauria; Dolichosauriidæ.
Rhiptoglossa; Chamæleonidæ.
Acrodonta; Agamidæ.
Iguania; Iguanidæ, Anolidæ.
Diploglossa; Zonuridæ, Pygopodidæ, Anguidæ, Xenosauridæ, Helodermidæ.
Thecaglossa; Varanidæ.
Uroplatoidea; Uroplatidæ.
Nyctisauria; Eublepharidæ, Gecconidæ.
Leptoglossa; Xantusiidæ, Teidæ, Lacertidæ, Gerrhosauridæ, Scincidæ, Acontiidæ, Anelytropidæ.
Annielloidea; Aniellidæ.
Opheosauri; Chirotidæ, Amphisbænidæ, Trogonophidæ.

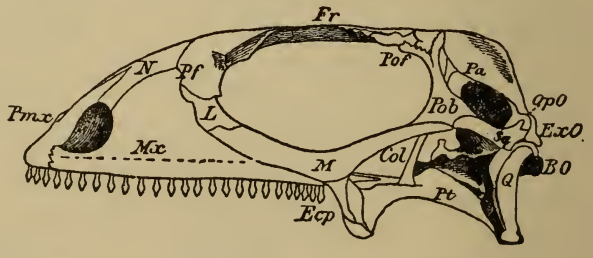


FIG. 25.—Skull of *Iguana tuberculata* Linn; external side view, natural size.

The recent forms of the Lacertilia are much more numerous than the known fossil forms. The geological distribution of the latter is shown in the following table:

1
2
3
4
5
6
7
8
9
10
11
Plistocene .
Neocene .
Eocene . .
Cretacic .
Jurassic .
Triassic .
Carbonic .
Devonic .
Siluric . .
Ordovicic .
Cambric .
Huronic .

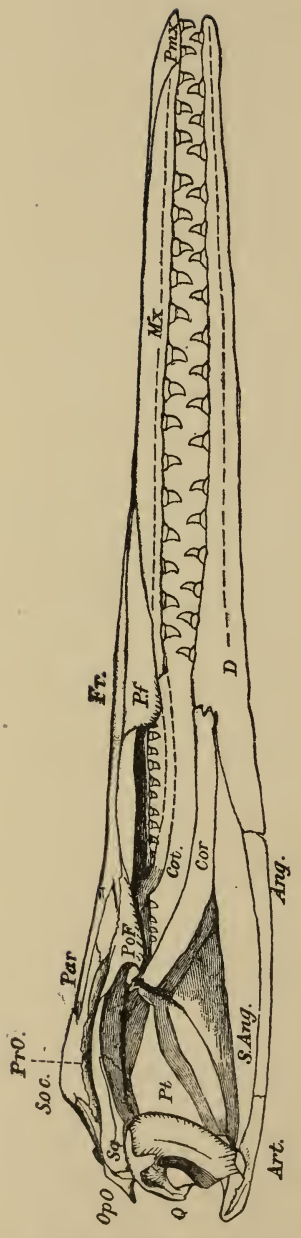


FIG. 26.—*Clidastes propython* Cope; skull, one-half natural size. From the Upper Cretaceous of Alabama.

The Dolichosauria are only known from European formations. Some of the species are snake-like in form. Acrodonta are best known from the same region, but one species is known from the American Eocene. It may belong to the Rhiptoglossa. The extinct Iguania and Leptoglossa are all European as far as known, while Diploglossa are known from both continents.

The PYTHONOMORPHA (Fig. 26) include two families, the Mosasauridæ and the Plioplatecarpidæ. The Mosasauridæ were the predominant type of sea-saurians during the Cretaceous period in North America, and they were common in Europe and in New Zealand, and some species have been found in Brazil. The Plioplatecarpidæ are only known from the Upper Cretaceous in Europe. Some of the species of Mosasaurus and Liodon reached a length of fifty feet. Their limbs were short, inflexible paddles, and the pelvic bones were very slender and feeble.

The OPHIDIA include the following superfamilies:

A. Supratemporal intercalated in the cranial walls. (*Angiostomata.*)

a, No ectopterygoid; palatines bounding choanæ posteriorly; ethmoturbinal forming part of roof of mouth; rudiments of a pelvis. (*Scolecophidia.*)

Maxillary bone fixed to prefrontal and premaxillary; a pelvis;

(1) *Catodonta* (blind snakes).

Maxillary bone vertical and free from all others; no pelvis;

(2) *Epanodonta* (blind snakes).

aa, An ectopterygoid; palatines not bounding choanæ posteriorly.

Maxillary bone free, horizontal;

(2) *Tortricina.*

AA. Supratemporal attached scale-like to cranial walls, produced freely posteriorly; ectopterygoid present. (*Eurystomata.*)

Maxillary bone bone horizontal, in contact with the premaxillary, and furnished with solid teeth; no rudiments of pelvis; (4) *Asinea* (harmless snakes).

Maxillary bone horizontal, thickened in front, and not reaching premaxillary, and bearing a perforate tooth; (5) *Proteroglypha* (cobras).

Maxillary bone vertical, not reaching premaxillary, articulating with the prefrontal by a ginglymus, and to the ectopterygoid without imbrication, and bearing a perforated tooth; (6) *Solenoglypha* (vipers and pitvipers).

The families embraced by these superfamilies are as follows:

Catodonta; Stenostomidæ.
Epanodonta; Typhlopidæ.
Tortricina; Tortricidæ, Uropeltidæ.
Asinea; Xenopeltidæ (Fig. 27), Pythonidæ, Boidæ, Charinidæ, Achrochordidæ; Nothopidæ, Colubridæ.
Proteroglypha; Hydrophidæ, Najidæ, Elapidæ, Dendraspididæ.
Solenoglypha; Causidæ, Atractaspididæ, Viperidæ, Crotalidæ.

The paleontology of the snakes is very imperfectly known. The oldest known genus, Symoliophis Sauv., from the Neocomian of France, may be either one of the Catodonta or Epanodonta. The oldest forms of Asinea (harmless snakes) are Pythonidæ and Boidæ; they occur in

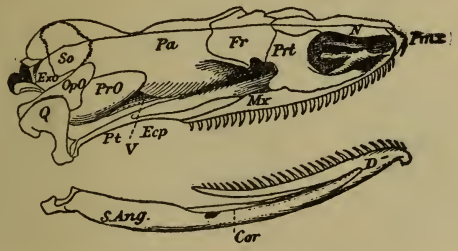


FIG. 27.—*Xenopeltis unicolor* Reinwt. Recent, from Siam; skull, natural size. Original. (Asinea.)

both continents. The largest are the species of Paleophis Owen, which occur in the Eocene of New Jersey and England; they equaled the largest existing pythons in dimensions (Fig. 28). The venomous snakes appear in the Neocene in both Europe and North America.

The geological distribution of the superfamilies of snakes is as follows:

	1	2	3	4	5	6
Plistocene .						
Neocene .						
Eocene . .						
Cretacic .						
Jurassic .						
Triassic .						
Carbonic .						
Devonic .						
Siluric . .						
Ordovicic .						
Cambric .						
Huronic .						

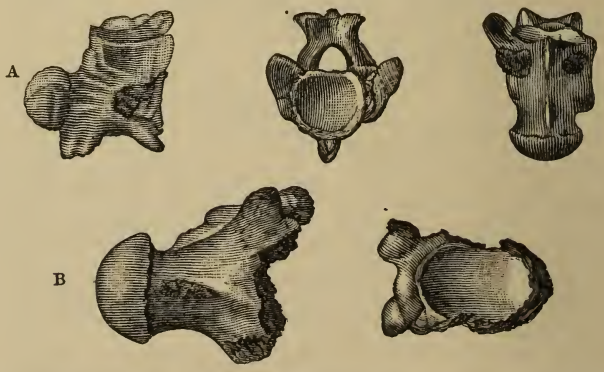


FIG. 28.—*A, Palæophis littoralis* Cope; *B, P. halidanus* Cope; vertebræ. Both from the Eocene of New Jersey.

Subclass II.—AVES.

There are two superorders of the birds, as follows:

Metacarpal and carpal bones all distinct, the digits with ungues; caudal vertebræ numerous, unmodified; clavicles united; pelvic elements distinct; teeth present; *Saururæ.*

FIG. 29.—*Archæopteryx lithographica* Wagn. From Middle Oölite of Bavaria, much reduced. From Dames.

Metacarpal and carpal bones reduced in number, coössified; ungues wanting or single; caudal vertebræ reduced in number, the terminal areas usually coössified; *Eurhipiduræ.*

The SAURURÆ includes but one order, which is defined as follows:

Vertebræ biconcave; feathers arranged in one series on each side of the caudal vertebræ; teeth present; *Ornithopappi.*

To this order but one family belongs, viz., the Archæopterygidæ.

This family is represented by one genus, Archæopteryx from the Oölite (Middle Jurassic) of Solenhofen, Bavaria. It was furnished with long feathers on the wings, adapting it for flight, and the long lizard-like tail had a row of long feathers on each side of it. It is the oldest known type of birds, and is an important one as showing the near connection of birds with reptiles. (Fig. 29.)

The EURHIPIDURÆ include four or five tribes which differ as follows:

Ischium free from ilium posteriorly;* palate dromæognathous (*i. e.*, maxillopalatines articulating with vomer which is between them, palatines not articulating directly with sphenoid rostrum); no teeth; (1) *Ratitæ.*

Ischium free from ilium posteriorly; palate ? dromæognathous; teeth; (2) *Odontolcæ.*

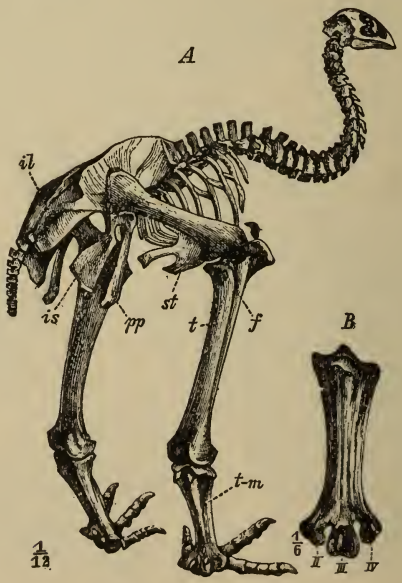


FIG. 30.—*Dinornis parvus* Owen. From Plistocene of New Zealand. From Owen. *Il*, ilium; *is*, ischium; *pp*, pubis; *st*, sternum; *B*, tarsometatarsus.

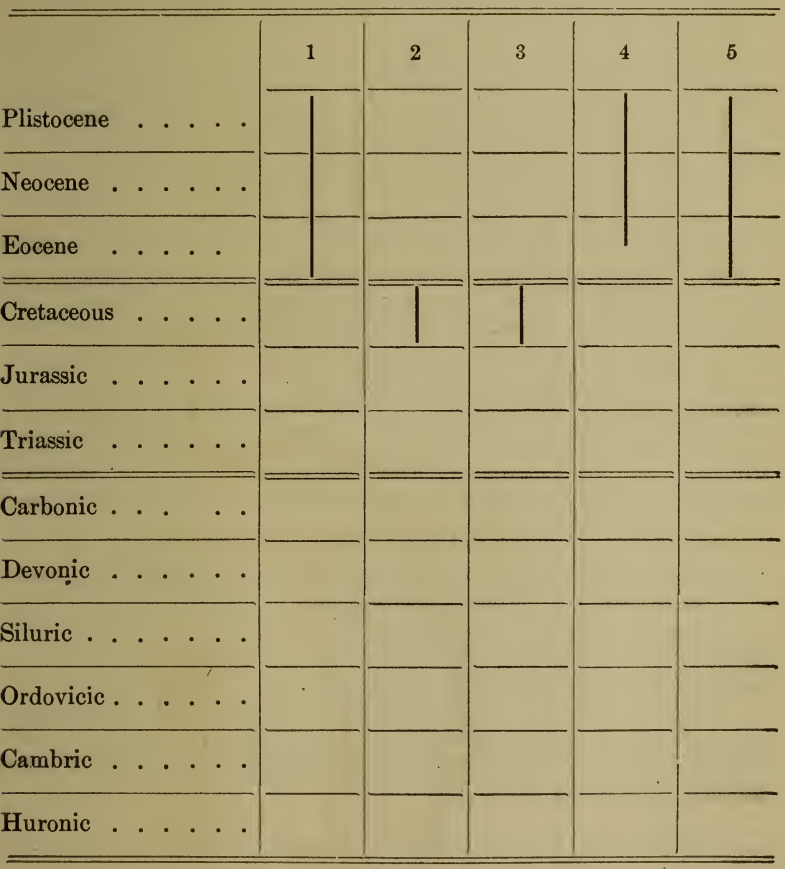
* With some apparent exceptions.

Ischium free from ilium posteriorly; palate ? not dromæognathous; teeth; (3) *Odontotormæ.*

Ischium coössified with ilium posteriorly; palate not dromæognathous; feathers distributed in area, those of the wings much differentiated; (4) *Euornithes.*

Ischium coössified with ilium; no teeth; feathers universally distributed and not differentiated on wings; (5) *Impennes.*

The Ratitæ are the ostriches and their allies; the Odontolcæ and Odontotormæ are toothed birds; the Impennes are the penguins, and the Euornithes are the remaining, or typical birds. The geological distribution of these tribes is as follows:



The tribe Odontolcæ includes but one order.

Teeth in a grove; sternum without keel; wings rudimental; pelvic bones free posteriorly; vertebræ saddle-shaped; *Dromæopappi.*

The Dromæopappi has but one family, the Hesperornithidæ, which have been only found so far in the Upper Cretaceous of Middle North America. They have many of the characters of the divers (order Cecomorphæ).

To the Odontotormæ one order only is referred. It is thus characterized:

Teeth in sockets; sternum keeled; wings well developed; ischium and pubis free posteriorly; vertebræ biconcave; *Pteropappi.*

The family of the Ichthyornithidæ is the only one known to belong to the Pteropappi. Its members are known from the Upper Cretaceous of North America and the Lower Cretaceous of England.

To the Impennes but one order belongs. This is the Ptilopteri.

Ilium not anchylosed with sacrum; bones of wing not foldable on each other; metacarpals not separated; hallux directed forwards; feathers scale-like; vertebræ opisthocœlous; *Ptilopteri.*

The Ptilopteri includes the recent family of the Aptenodytidæ or penguins. They first appear in the Upper Eocene of New Zealand. No species, living or extinct, have been found in the Northern Hemisphere.

The Ratitæ includes the following orders:

Sternum without keel; clavicles; wings rudimental; *Struthiones.*
Sternum without keel; no clavicles; wings rudimental; *Apteryges.*
Sternum with keel; clavicles; wings rudimental; *Gastornithes.*
Sternum with keel; clavicles; wings functional; *Crypturi.*

The families belonging to these orders are the following:

Struthiones; Struthionidæ (ostriches), Rheidæ, Casuariidæ, Dromæidæ, Dinornithidæ (Fig. 30), Æpiornithidæ.
Apteryges; Apterygidæ (kiwis).
Gastornithes; Gastornithidæ.
Crypturi; Crypturidæ (tinamus).

Of the above families the Struthionidæ are remarkable in having the pubes forming a ventral symphysis. The Rheidæ are equally remarkable in having a ventral symphysis of the ischia. The geological range of these orders is as follows:

	Struthiones	Apteryges	Gastornithes	Crypturi
Plistocene				
Neocene				
Eocene				
Cretacic				
Jurassic				
Triassic				
Carbonic				
Devonic				
Siluric				
Ordovicic				
Cambric				
Huronic				

Extinct Struthiones are known from all the great regions of the Old World, but none from the New. The extinct Apteryges come from the Australian realm only. The Gastornithes are known from the Eocenes of both Europe and North America. Gastornis has persistent sutures of the skull, and a tooth-like process on the upper jaw. *G. edwardsii* was nine feet high. The species of Dinornis from the Plistocenes of New Zealand were all of large size, some of them reaching twelve feet in height. One species is known from Australia.

The Euornithes include numerous suborders, which are defined as follows:

I. Maxillopalatines united across the middle of the palate. (*Desmognathæ*).

A. Four toes directed forwards (pamprodactylous).

Toes webbed; no basipterygoids; (1) *Steganopodes.*

Toes free; vomer unossified; no basipterygoid processes; (2) *Colioïdei.*

AA. Three toes directed forwards.*

Short basipterygoid processes; toes generally webbed; præcocial; (3) *Chenomorphæ.*

No basipterygoid processes; bill and legs slender; toes generally free; altricial; (4) *Herodii.*

Bill and claws hooked; toes free; vertebræ saddle-shaped; altricial; (5) *Accipitres.*

Bill hooked; toes free; vertebræ opisthocœlous; rostrum movably articulated with skull; basipterygoids; (6) *Heterospondyli.*

Toes free; vertebræ saddle-shaped; rostrum fixed; (7) *Coccygomorphæ.*

AAA. First and fourth toes directed backwards (zygodactylous).

Rostrum freely articulated with the skull; vertebræ opisthocœlous; (8) *Psittaci.*

AAAA. First and second toes directed backwards (heterodactylous).

Basipterygoids present; heteropelmous; (9) *Trogonoidei.*

II. Maxillopalatines not united across the palate; vomer narrowed and acute in front. (*Schizognathæ.*)

A. Toes three forwards (anisodactylous).

Schizorhinal; toes webbed; (10) *Cecomorphæ.*

Toes free; legs long; feathers with after shaft; præcoces; (11) *Grallæ.*

No basipterygoids; lachrymal bones coössified with rostrum; toes free; (12) *Opisthocomi.*

Toes free; hallux rudimental; (13) *Gallinæ.*

Toes free; hallux well developed; two carotids; (14) *Pullastræ.*

Toes free; hallux well developed; one carotid artery; basipterygoids; (15) *Micropodioidei.*

AA. First and fourth toes directed backwards (zygodactylous).

No cæca coli; no interclavicle; one carotid; (16) *Picoidei.*

III. Maxillopalatines not united on median line; vomer single, truncate, and excavated in front. (*Ægithognathæ.*)

A. Toes three in front (anisodactylous).

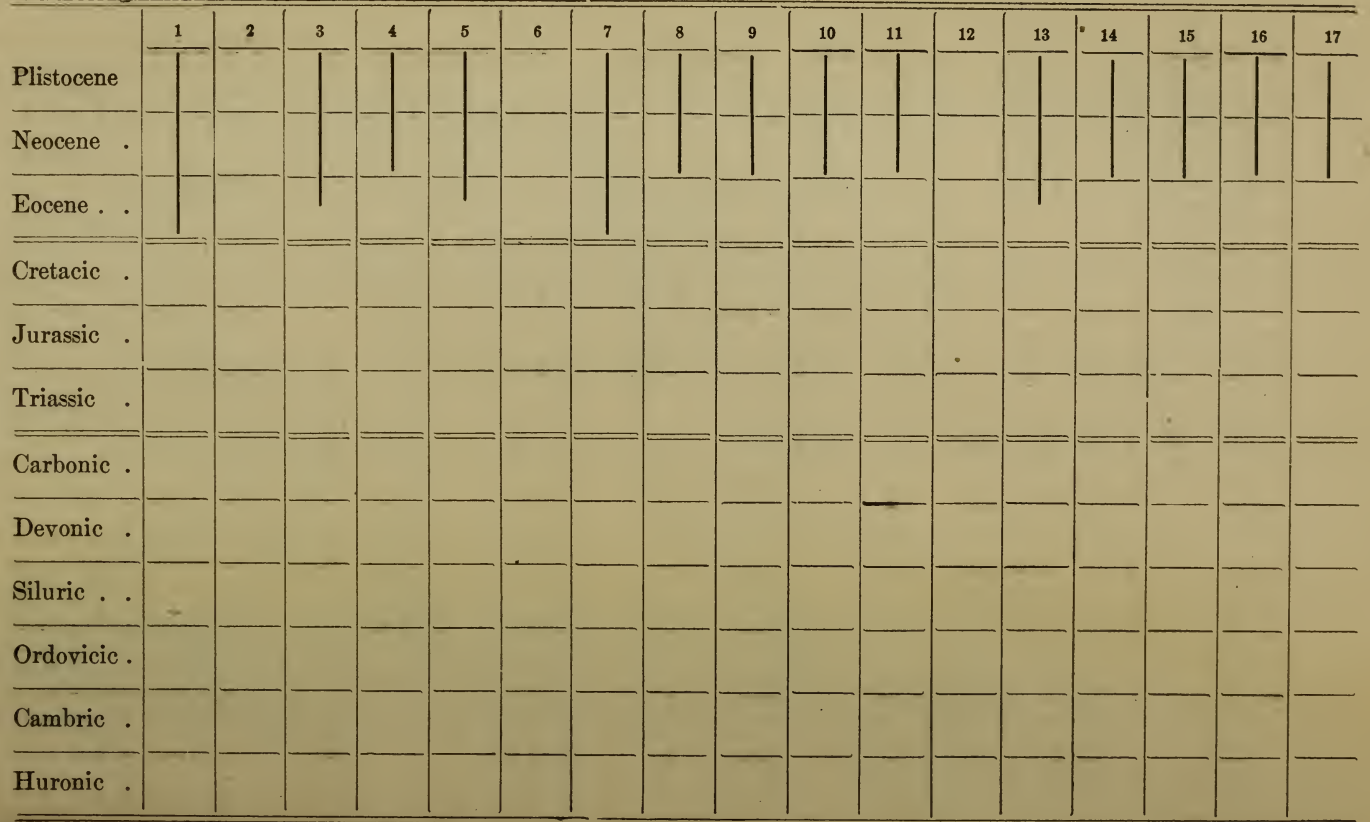
Toes free; hallux well developed; tarsometatarsus with five tendinous canals; basipterygoids wanting or rudimental; sternum with two notches; no cæca coli; one carotid artery; (17) *Passeres.*

AA. Four toes directed forwards (pamprodactylous).

Toes free; no basipterygoids; sternum entire posteriorly; tensor patigii brevis muscle attached to a tendon which extends to the manus; no cæca; (15) *Micropodioidei.*

The time distribution of the Euornithes is as follows, as far as known:

* Except Cuculidæ and Rhamphastidæ, which are zygodactylous.


1
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14
15
16
17
Plistocene
Neocene .
Eocene . .
Cretacic .
Jurassic .
Triassic .
Carbonic .
Devonic .
Siluric . .
Ordovicic .
Cambric .
Huronic .

The cormorants, pelicans, and boobies of the Steganopodes appear in the Eocene. The Eocene representatives of the Chenomorphæ are primitive flamingoes, the true ducks and geese not appearing before the Neocene. The Eocene Accipitres are Falconidæ, the owls not appearing before the Neocene. The kingfishers are the earliest representatives of the Coccygomorphæ appearing in the Eocene; the remaining families are not known prior to the Neocene. The Phasianidæ of the Gallinæ appear in the Middle Eocene. It is thus evident that the majority of the families of the Euornithes are not known prior to the beginning of the Neocene system.

The families of the EUORNITHES are as follows:

Steganopodes; Phætonidæ, Fregatidæ, Pelecanidæ, Sulidæ, Phalacrocoracidæ, Plotidæ.
Chenomorphæ; Palamedeidæ, Anatidæ, Phœnicopteridæ.
Herodii; Ibididæ, Ciconiidæ, Balænicipitidæ, Ardeidæ.
Accipitres; Cathartidæ, Falconidæ, Pandionidæ, Strigidæ.
Psittaci; Psittacidæ.
Trogonoidei; Trogonidæ.
Cecomorphæ; Colymbidæ, Heliornithidæ, Alcidæ, Laridæ, Procellariidæ.
Grallæ; Chionidæ, Thinocoridæ, Glareolidæ, Dromadidæ, Charadriidæ, Otididæ, Eurypygiidæ, Rhinochetidæ, Cariamidæ, Psophiidæ, Gruidæ, Rallidæ.
Opisthocomi; Opisthocomidæ.
Gallinæ; Tetraonidæ, Phasianidæ.
Pullastræ; Cracidæ, Megapodiidæ, Pteroclidæ, Dididæ, Columbidæ.
Colioidei; Coliidæ.
Heterospondyli; Steatornithidæ.
Coccygomorphæ; Cuculidæ, Coraciidæ, Alcedinidæ, Upupidæ, Musophagidæ, Todidæ, Momotidæ, Bucerotidæ, Rhamphastidæ, Caprimulgidæ, Bucconidæ, Indicatoridæ.
Micropodioidei; Cypselidæ, Trochilidæ.
Picoideæ; Picidæ, Yngidæ.

Passeres. This order is divided into five superfamilies, as follows:

Tensor patagii brevis picarian; — *Menuroidei.*

Tensor patagii brevis passerine; syrinx,
- Mesomyodian,
  - desmopelmous; — *Eurylæmoidei.*
  - bronchiotracheal; schizopelmous. — *Tyrannoidei.*
  - tracheal; schizopelmous. — *Formicaroidei.*
- Acromyodian, schizopelmous; — *Passeroidei.*

The families of these superfamilies are the following:

Menuroidei; Menuridæ, Atrichornithidæ.
Eurylæmoidei; Eurylæmidæ.
Tyrannoidei; Xenicidæ, Philepittidæ, Pittidæ, Tyrannidæ, Cotingidæ, Phytotomidæ.
Formicaroidei; Conopophagidæ, Pteroptochidæ, Formicariidæ.

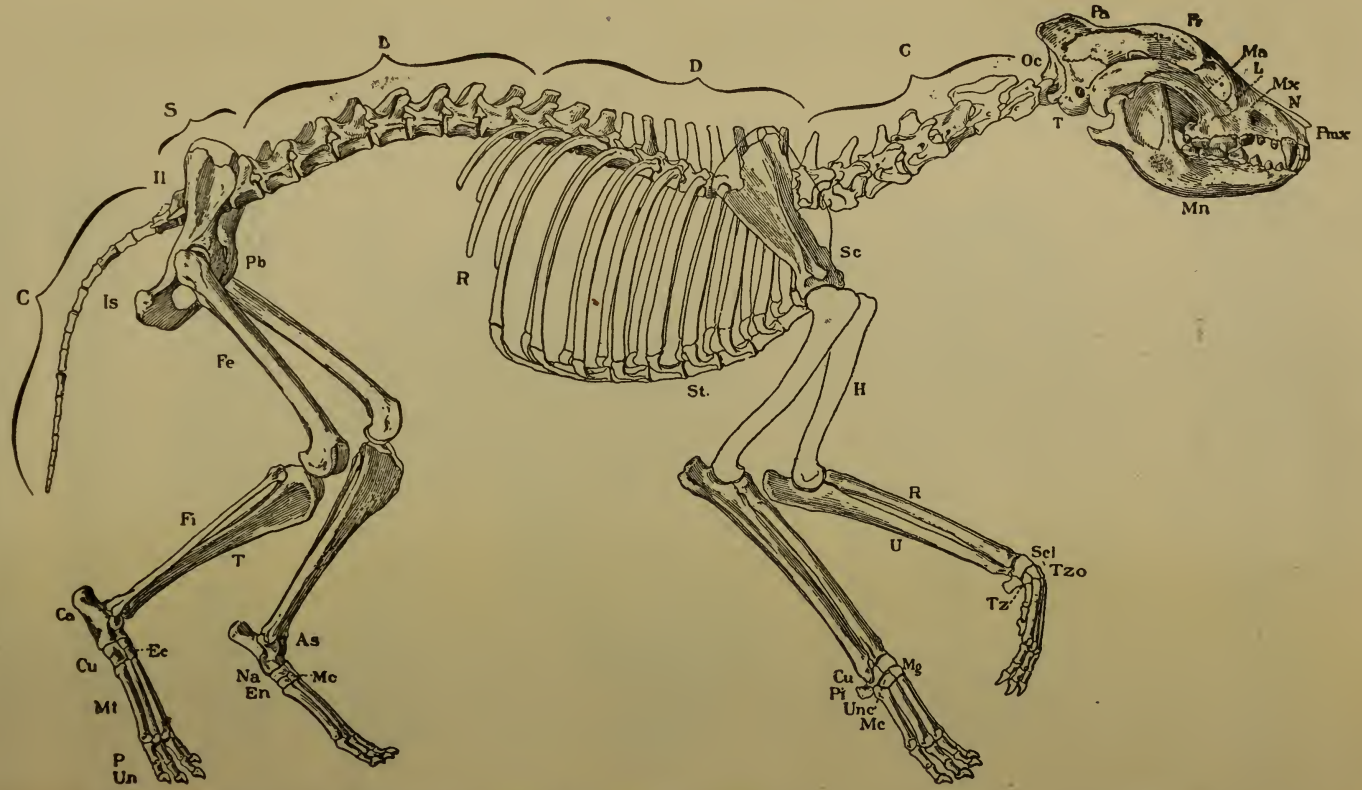


FIG. 31.—*Ælurodon sævus* Leidy; much reduced. Restored from skeleton in collection of E. D. Cope. The unshaded portions supplied. From the Loup Fork (Upper) Neocene of Nebraska.

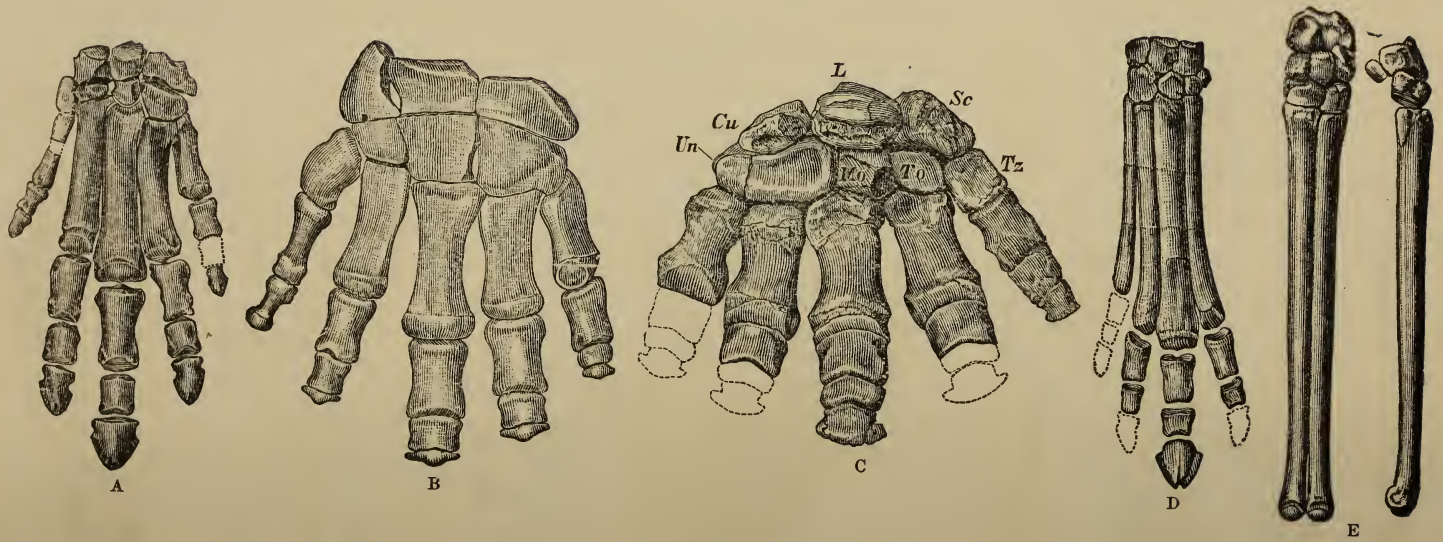


FIG. 32.

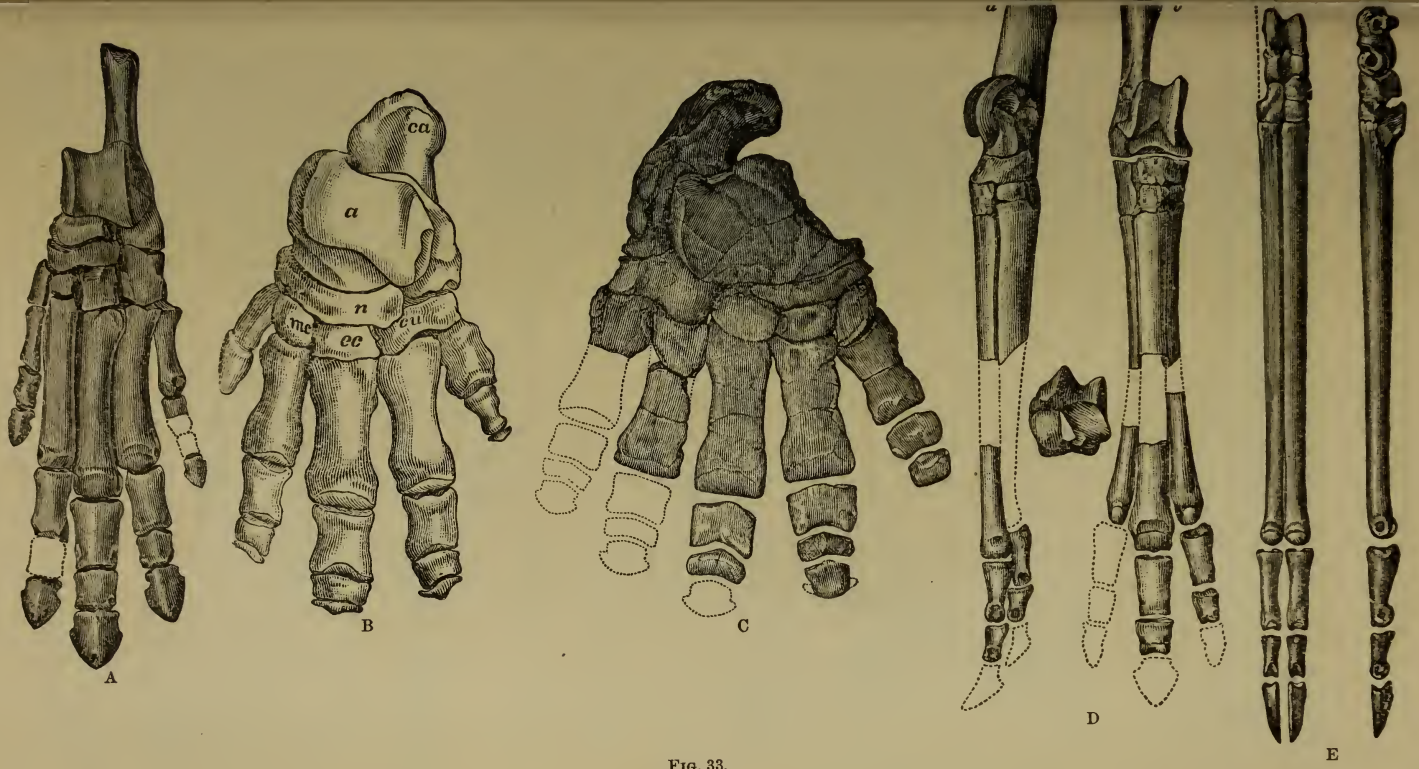


FIG. 33.

FIGS. 32 and 33.—*A, Phenacodus primævus* Cope; *B, Elephas africanus* Linn.; *C, Coryphodon elephantopus* Cope; *D, Hyracotherium venticolum* Cope; *E, Poëbrotherium labiatum* Cope.

Passeroidei; Alaudidæ Motacillidæ, Timaliidæ, Liotrichidæ, Muscicapidæ, Turdidæ, Cinclidæ, Troglodytidæ, Chamæidæ, Hirundinidæ, Artamidæ, Laniidæ, Paridæ, Paradisiidæ, Corvidæ, Sturnidæ, Meliphagidæ, Nectariniidæ, Certhiidæ, Ploceidæ, Tanagridæ, Icteridæ, Fringillidæ.

Class V.—MAMMALIA.

The primary characters of the Mammalia are seen in their limbs and in their teeth. The general characters of the skeleton may be learned from Fig. 30 (*Ælurodon sævus* Leidy). The mutilate type of limbs is seen in Fig. 37 (*Cetotherium cephalus* Cope). The phalanges are connected by integument and form an inflexible paddle, and in the typical forms the elbow is also inflexible. The difference between the unguiculate and ungulate phalanges may be seen by comparing Fig. 30 and Fig. 48 with Figs. 31 and 42. The compressed curved form of the former, adapted for prehension, is easily distinguished from the flat generally wide type seen in the latter, which is adapted for support. The different carpal and tarsal types of the Ungulata are seen in Figs. 31 and 32. A is the taxeopodous; B, the proboscidian; C, the amblypodous, and D and E the diplarthrous, represented by the Perissodactyla (D) and Artiodactyla (E) respectively.

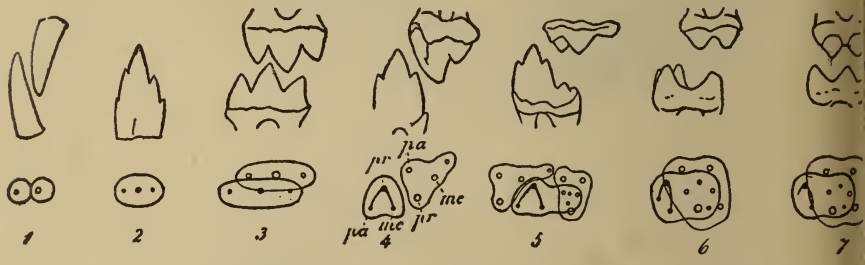


FIG. 34.—Diagrams of types of mammalian dentition, from Osborn; *1*, haplodont; *2*, protodont; *3*, triconodont; *4*, tritubercular superior and inferior; *5*, tritubercular superior, tuberculosectorial lower; *6*, quadritubercular superior, quinquetubercular inferior; *7*, quadritubercular, both jaws.

The molar types of dentition in historical and developmental order to the quadritubercular are represented in Fig. 34. Forms up to No. 5, inclusive, predominate in the Unguiculata; and 6 and 7 with their derivatives predominate in the Ungulata. The derivatives of Nos. 6 and 7 are formed by the development of ridges or crests which connect the cusps longitudinally or transversely, forming various patterns, two of which are represented in Figs. 53 and 58. Such types are termed lophodont. Those in which the crests and grooves between them become respectively elevated and profound are termed ptychodont (Figs. 41 and 56).

Two subclasses are known to belong to the Mammalia:

An interclavicle; a large coracoid articulating with the sternum; *Prototheria.*

No interclavicle; coracoid very small, coössified with scapula; not reaching sternum; *Eutheria.*

The Prototheria have an existing order, the Monotremata, and it is supposed, with much probability, that two orders which appear in the Trias and continue until the Eocene, inclusive, belong to it. If this classification is admitted, the Eutheria have their first representatives in the Postcretaceous, and their latest are now numerous.

Of the PROTOTHERIA, there are probably three orders of which species are known, but the location of the two first enumerated below is not certain.

Incisors reduced; molars with compressed cutting crowns, and undivided roots; *Protodonta.*

Incisors much enlarged; molars with tubercular grinding surfaces, and distinct roots; *Multituberculata.*

No true teeth at maturity; *Monotremata.*

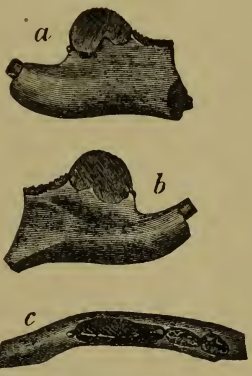


FIG. 35.—*Ptilodus mediævus* Cope; mandibular ramus; *a*, *b*, $\frac{1}{1}$; *c*, $\frac{3}{2}$. Original. From Puerco bed of New Mexico.

The families are the following:

Protodonta; Dromatheriidæ.

Multituberculata; Tritylodontidæ, Plagiaulacidæ, Chirogidæ, Polymastodontidæ.

Monotremata; Ornithorhynchidæ.

The geological range of these orders is shown by the table on next page.

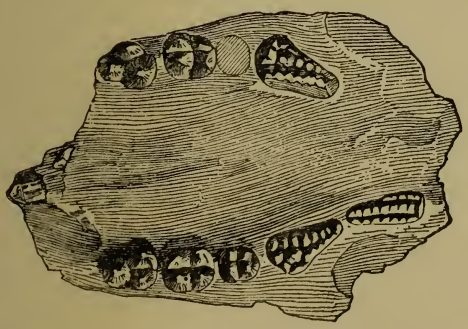
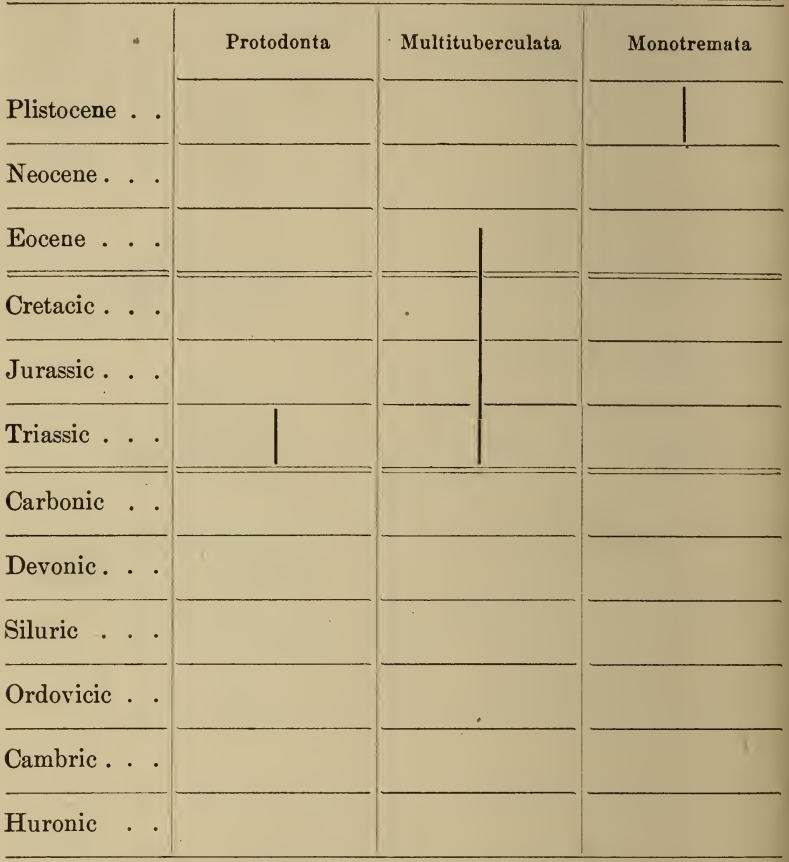


FIG. 36.—*Chirox plicatus* Cope; palate and molar teeth, from below, 3–2 natural size. From Puerco bed of New Mexico. Original.



Species of PROTODONTA have been found thus far only in the Triassic beds of North Carolina. Their molar teeth bear some resemblance to those of some of the corresponding teeth of the Theromorous reptilian genus Dimetrodon. The oldest MULTITUBERCULATA appear in the Trias of South Africa in the Karoo beds, and in the Upper Trias (Keuper) of Würtemburg (Europe). They are more abundant in the Jurassic of England and of the Rocky Mountain region of America, and in the later Cretaceous of North America and of Patagonia. In the latest Cretaceous (Puerco) of New Mexico the largest forms occur, which equal an adult kangaroo. The last of them are found in the lowest Eocene in the north of France. Extinct and recent MONOTREMATA are restricted to the Australian realm.

The EUTHERIA are represented by the following numerous orders:

I. Marsupial pelvic bones (generally); palate perforated; (vagina double; placenta wanting; corpus callosum rudimental; cerebral hemispheres small.) (*Didelphia.*)

One deciduous molar tooth ; (1) *Marsupialia.*

II. No marsupial bones; palate generally entire; (one vagina; placenta and corpus callosum well developed.) (*Monodelphia.*)

A. Posterior limbs wanting, or represented by minute rudiments ; anterior limbs oar-like. (*Mutilata.*)

Elbow joint inflexible; carpals discoid, and, with the phalanges, separated by cartilage; lower jaw without ascending ramus ; (2) *Cetacea.*

Elbow joint flexible; carpals and phalanges with close articulations; mandible with ascending ramus ; (3) *Sirenia.*

AA. Posterior limbs present; ungual phalanges compressed and curved on one or all the feet.* (*Unguiculata.*)

β, Carpal and tarsal bones generally in linear series.

γ, Teeth without enamel; no incisors.

Limbs ambulatory; hemispheres small; (4) *Edentata.*

$\gamma\gamma$, Teeth with enamel; incisors present.

No postglenoid process; mandibular condyle not transverse; mastication proal; limbs not volant; hemispheres small; (5) *Glires.*

Anterior limbs volant; hemispheres small; (6) *Chiroptera.*

A postglenoid process; mandibular condyle transverse; mastication orthal; no scapholunar bone; † hemispheres small, smooth ; (7) *Bunotheria.*

A postglenoid process; limbs not volant, with a scapholunar bone; mastication orthal; hemispheres larger, convoluted ; (8) *Carnivora.*

$\beta\beta$, Carpal and tarsal bones alternating; faceted.

Anterior limbs prehensile; mandibular condyle and mastication transverse ; (9) *Ancylopoda.*

AAA. Posterior limbs present; ungual phalanges not compressed and hooked. ‡ (*Ungulata.*)

β, Carpal, and usually tarsal bones in linear series. §

Limbs ambulatory; teeth with enamel ; (10) *Taxeopoda.*

$\beta\beta$, Carpal bones alternating externally ; tarsals in linear series.

Limbs ambulatory, median digits longest; teeth with enamel ; (11) *Toxodontia.*

$\beta\beta\beta$, Tarsal bones alternating; carpals linear or reversed diplarthrous.

Cuboid bone partly supporting navicular, not in contact with astragalus; no canine teeth ; (12) *Proboscidea.*

$\beta\beta\beta\beta$, Both tarsal and carpal series more or less alternating ; the distal row inwards.

Os magnum not supporting scaphoides; cuboid supporting astragalus; superior molars tritubercular; (13) *Amblypoda.*

Os magnum supporting scaphoides; superior molars quadritubercular; || (14) *Diplarthra.*

* Except Mesonychidæ, some Glires, and posterior feet of some Edentata. † Except Talpa and Erinaceus. ‡ Except in the Hapalidæ. § Except in Dendrohyrax. || Except Pantolestidæ.

The geological range of these orders is as follows:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plistocene														
Neocene														
Eocene														
Cretacic	?													
Jurassic														
Triassic														
Carbonic														
Devonic														
Siluric														
Ordovicic														
Cambric														
Huronic														

The Marsupialia fall into two suborders, which differ as follows:

Incisors $\frac{4-5}{3-4}$ *Polyprotodontia.*

Incisors $\frac{1-3}{1}$ *Diprotodontia.*

The Polyprotodontia are carnivorous and insectivorous in their habits, and their present range is Australasia and the two Americas. They are the older of the suborders, being represented in the Eocenes of Europe and North America by species of opossums. Genera probably allied occur in the Postcretaceous of North America. No large forms are known. The Diprotodontia are now restricted to Australasia, and the extinct forms belong to the Plistocene of the same region. These include some very large kangaroos, with still larger animals of the genera Nototherium and Diprotodon. The *Diprotodon australis* Owen was as large as a rhinoceros, but though allied to the kangaroo, was typical of a different family. The feet were plantigrade, and the fore limbs were larger than the hind limbs.

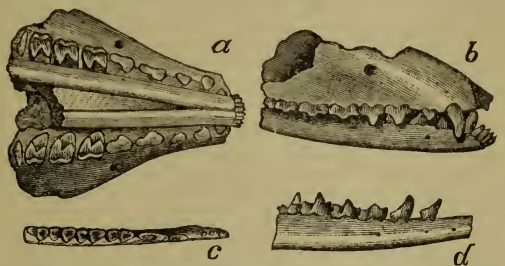


FIG. 37.—*Peratherium fugax* Cope; anterior part of skull. From Lower Neocene (White River bed) of Colorado. X 2. Original.

The CETACEA are represented by three suborders, which differ as follows:

External nostrils at middle of muzzle; temporal fossæ elongate approximated; teeth; *Archæoceti.*

External nostrils at base of muzzle; temporal fossæ short, lateral; teeth; *Odontoceti.*

External nostrils at base of muzzle; temporal fossæ short, lateral; no teeth, but transverse horny laminæ on the upper jaw; *Mysticeti.*

FIG. 38.—*Zeuglodon cetoides* Owen; skull, much reduced. From Eocene of Alabama. From Gaudry.

The Archæoceti are few in number, and are chiefly represented by the gigantic Zeuglodon. They are not known before or after the Eocene system, nor out of the geographical area of the Northern Hemisphere. The Odontoceti first appear in the older Neocene, and the oldest family, the Squalodontidæ, have the posterior teeth two-

rooted, as in the Zeuglodons. The other families with one-rooted teeth were contemporary with them, and are represented in the present seas by numerous types, as the dolphins, sperm whales, etc. The Mysticeti, or whalebone whales, appear in the Lower Neocene, and are still abundant. They include the largest vertebrates. (Fig. 39.)

Sirenia first appear in a very generalized family in the Eocene beds of some West Indian Islands. In the Neocene of Europe and North America forms approaching more nearly to the existing types are not rare, especially in the south of Europe. At present species exist on the shores of all the continents in the warmer latitudes. (Fig. 40.)

The Edentata have been generally restricted to the Southern Hemisphere, although during the Neocene they ranged as far north as the Ægean Sea in Europe, and to latitude 46° in North America during the Plistocene. They first appear in the Eocene of Patagonia, and were extremely common in the Neocene throughout tropical America, where they are still abundantly represented. A few species still remain in the Ethiopean and Paleotropical geographical realms. The Megatheriidæ of the South American Neocene were of large and gigantic size, the largest species pertaining to the genus Megatherium, which ranged in North America to South Carolina. The Glyptodontidæ were covered with an immovable carapace consisting of bony tesseræ, somewhat like that of the armadillos. They varied in size from that of a sheep to that of a rhinoceros. Species were abundant in the Neocene of South America, when they also ranged north to Texas, Florida, and Kansas. The most ancient (Eocene) Edentata display traces of enamel on the teeth.

The Glires are found in the strata of all regions, but in reduced numbers in the Eocenes in all countries except temperate South America, where they were very abundant at that age. There are four suborders, which differ as follows:

I. Fibula not articulating with calcaneum; ankle and elbow not tongued and grooved; one pair of incisors in upper jaw.

Incisive alveolus not passing into center of ramus of lower jaw; fibula distinct; *Hystricomorpha.*

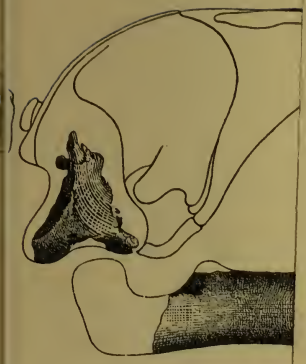
Incisive alveolus penetrating ramus; fibula distinct; *Sciuromorpha.*

Incisive alveolus penetrating ramus; fibula coössified with tibia; *Myomorpha.*

II. Fibula articulating with calcaneum; ankle and elbow tongued and grooved; two incisors in upper jaw.

Inferior incisor penetrating ramus; fibula coössified; *Lagomorpha.*

The Hystricomorpha (porcupines, cavies, etc.) are abundant in the Eocene of South America, and are present in the Upper Eocene of France. They are more abundant in the Neocene of South America and France, and are present in the Upper Neocene of North America. At present they are cosmopolitans, excepting Australia, but they chiefly abound in South America. (Fig. 41.) The Sciuromorpha only occur fossil in the



b

yland. Original. (Cetacea.)

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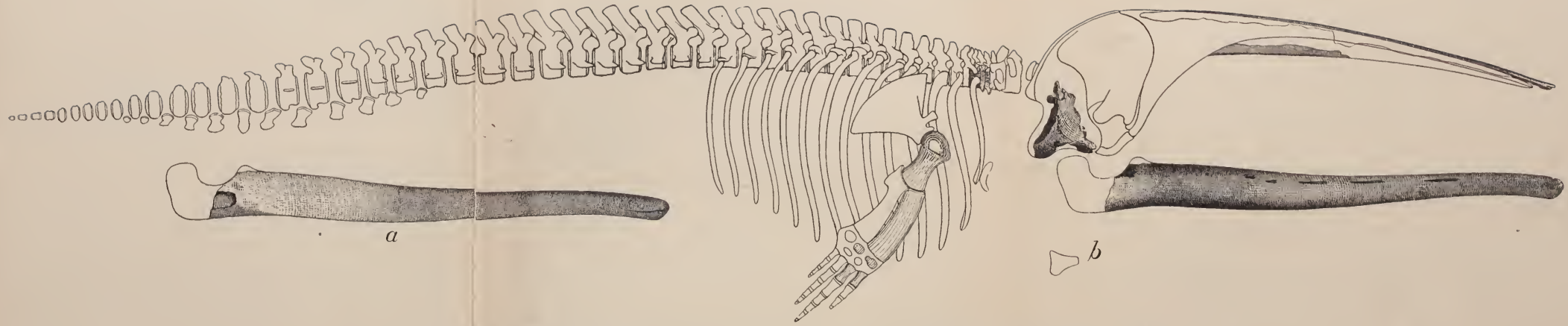


FIG. 39.—*Cetiosaurus cephalus* Cope; restored skeleton, much reduced; the shaded parts only known. From the Neocene of Maryland. Original. (Cetacea.)

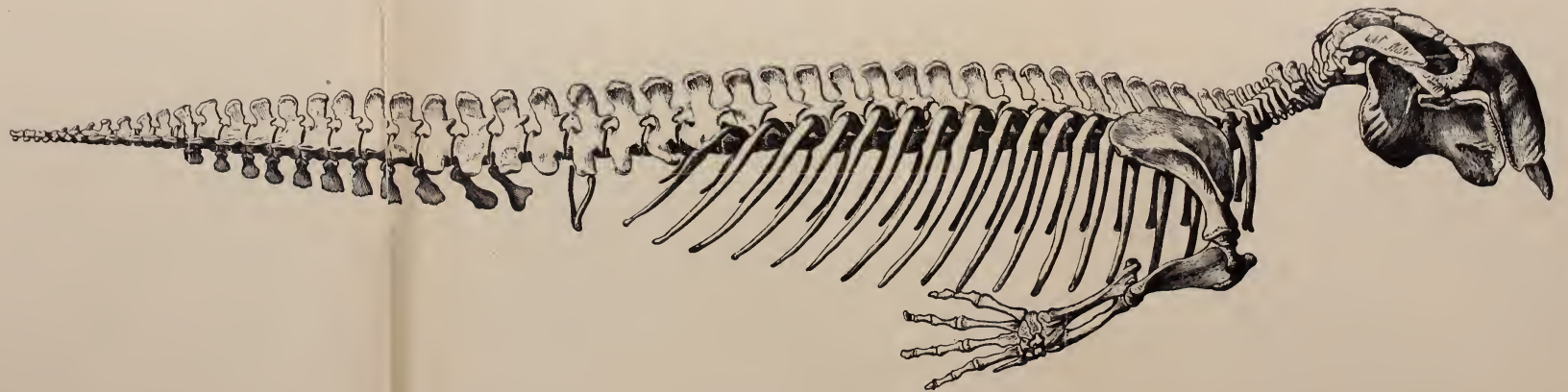


FIG. 40.—*Halicore dugong* Cuv.; skeleton, much reduced. From Australasian seas. From Cuvier. (Sirenia.)

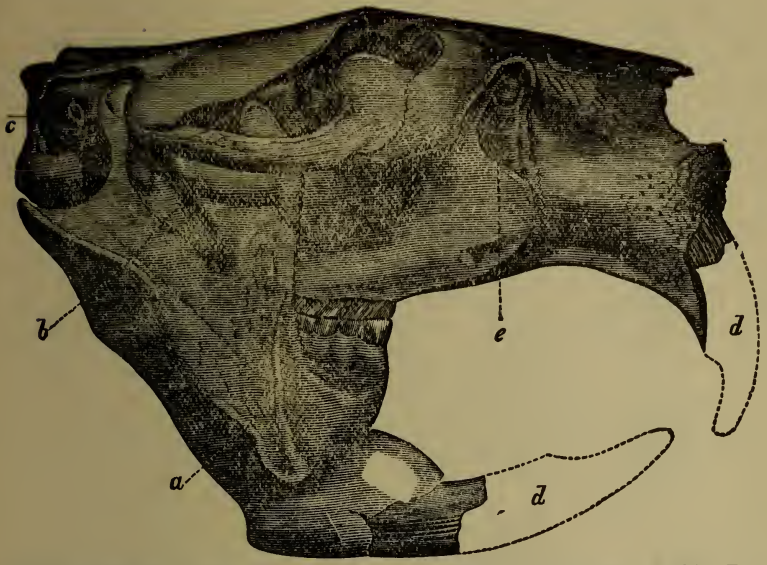


FIG. 41.—*Castoroides ohioensis* Foster; skull, much reduced. From Plistocene of Ohio. From Hall and Wyman.

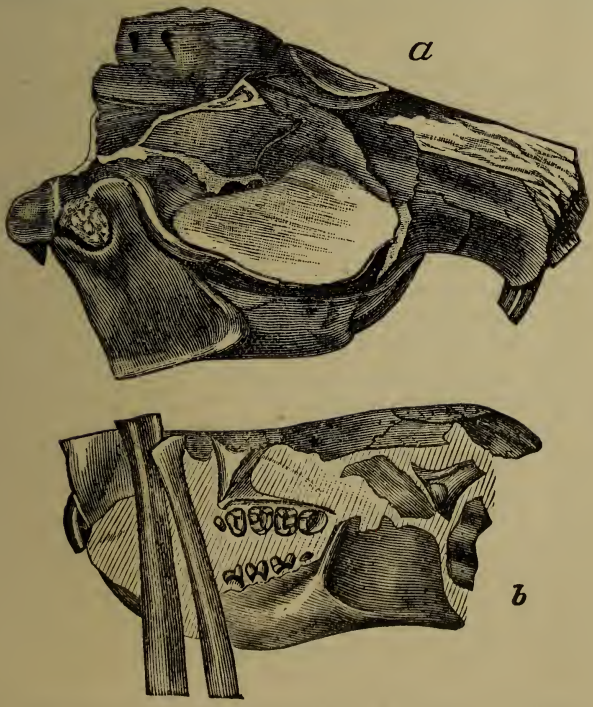


FIG. 42.—*Plesiarctomys delicatissimus* Leidy; skull. From Eocene of Wyoming. Original.

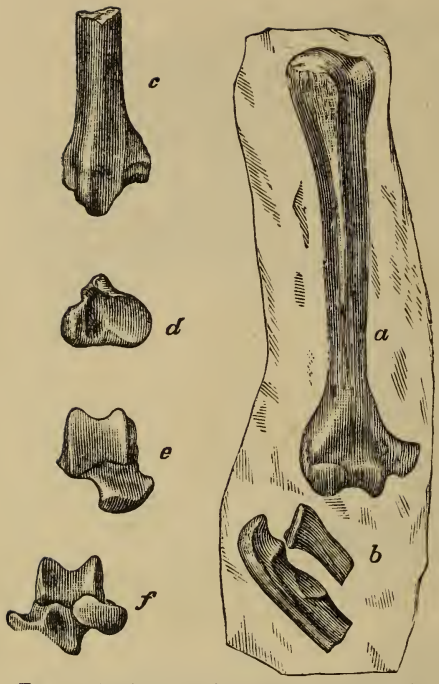


FIG. 43.—*Plesiarctomys delicatissimus* Leidy; *a*, humerus; *b*, proximal ends of ulna and radius; *c*, *d*, tibia, distal end; *e*, *f*, astragalus; all natural size. From Eocene of Wyoming.

Northern Hemisphere, and are the principal Glires of the Eocene. From that period they became more abundant in both North America and Europe, reaching their highest expression in the beaver, and spread into South America. (Figs. 42–43.)

The Myomorpha (mice, rats, etc.) have a few supposed representatives in the Eocene of Patagonia, but only begin in the Neocene in the Northern Hemisphere. The dor-mice are peculiar to European beds, and the pocket-gophers to North American. They cover the earth, including a few forms in Australia, at the present period. (Fig. 44.)

The Lagomorpha (rabbits) appear first in the lowest Neocene of North America (White River), and continue to the present day. They appear in Europe at about the same time, but not in South America until the Plistocene. (Fig. 45.)

The CHIROPTERA (bats) includes two primary divisions at the present time, the insectivorous (Animalivora), and the frugivorous (Frugivora), which differ as follows:

Crowns of molar teeth with Vs; those of opposite jaws interlocking in mastication; *Animalivora.*

Crowns of teeth obtuse, not interlocking in mastication; *Frugivora.*

The Frugivora (flying foxes) present a degenerate dentition, and they are not known in the fossil state. Animalivora, on the other hand, appear in typical forms in the Lower Eocene (Wasatch) in North America, and the Upper Eocene (phosphorites) in France.

The BUNOTHERIA present four suborders, which are characterized as follows:

Molars 8 or more; incisors several, with closed roots; *Pantotheria.*

Molars 7 or less; incisors with closed roots, not enlarged; fibula distinct; otic bulla developed; *Creodonta.*

Molars 7 or less; canine generally small, incisors generally enlarged; fibula generally united with tibia; *Insectivora.*

Molars 7 or less; incisors few, growing continually from open roots; *Tillodonta.*

The Pantotheria are the most ancient of the Eutherian Mammalia, appearing rather abundantly in the Jurassic of Europe and North America. They are all of small size. The Creodonta represent

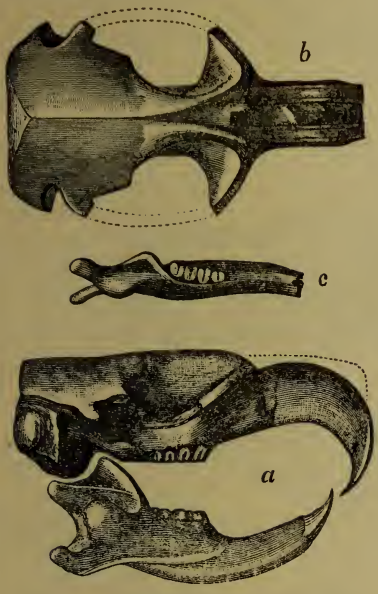


FIG. 44. — *Entoptychus crassiramis* Cope; a pocket-gopher from the Middle Neocene of Oregon, natural size. Original. *c*, lower jaw from above.

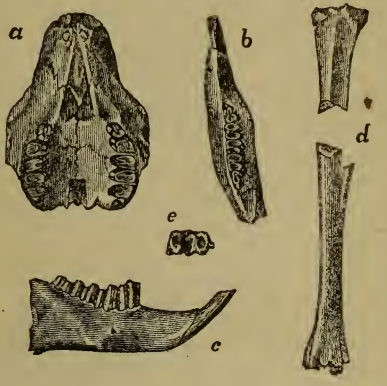


FIG. 45.—*Palæolagus haydenii* Leidy; a rabbit from the Lower Neocene of Colorado. Original; natural size. *a*, anterior half of skull, from below; *b*, *c*, lower jaw; *d*, tibia and fibula, from front; *e*, do., from below.

the Carnivora in the Postcretaceous and Eocene systems. They have (except in one family) more than one sectorial molar, and these are true molars, and not premolars. They have (except in one family) strong canines. They range in size from that of an opossum (Stypolophus sp.) to that of a grizzly bear (Hemipsalodon sp.). They are found in the horizons mentioned in North America, Europe, and South America. A few species (Hyænodon, etc.) remain over in the Lower Neocene (White River). (Fig. 46.)

Undoubted Insectivora appear in the Upper Eocene of France, but supposed members of the suborder occur in the Lower Eocene of the same. In America none are certainly known prior to the Lower Neocene (White River). They are rare in all formations in America, but they are abundant in the Middle Neocenes of Europe, and in later beds, where forms of moles, shrews, and hedgehogs are abundant. The enlargement of the incisors seen in the Insectivora reaches its extreme in the Tillodonta, where they grow from persistent pulps, as in the Glires. These animals first appear in the Postcretaceous of North

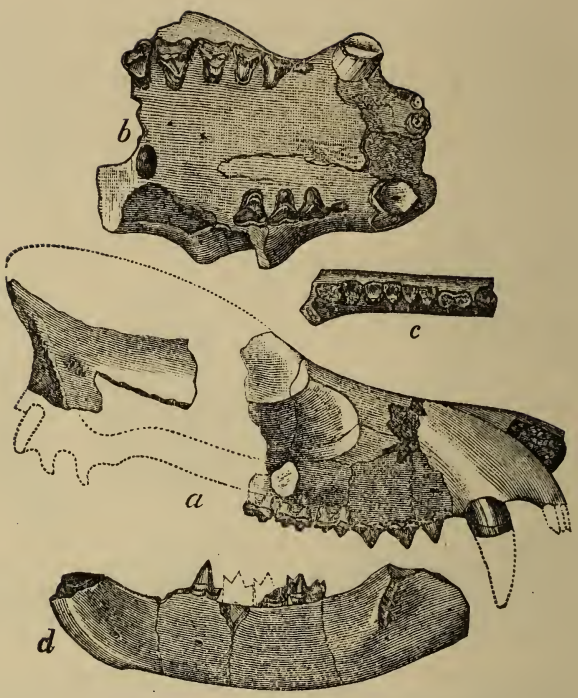


FIG. 46.—*Deltatherium fundaminis* Cope; portions of skull, two-thirds natural size. From Puerco bed of New Mexico. *a*, skull profile; *b*, from below; *c*, fragment of lower jaw, from above; *d*, do., from outer side.

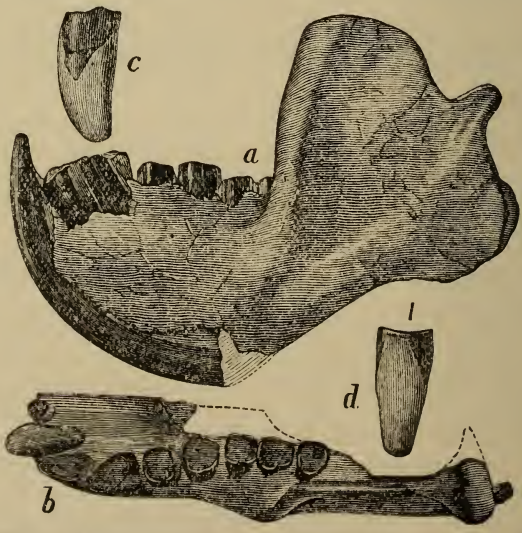
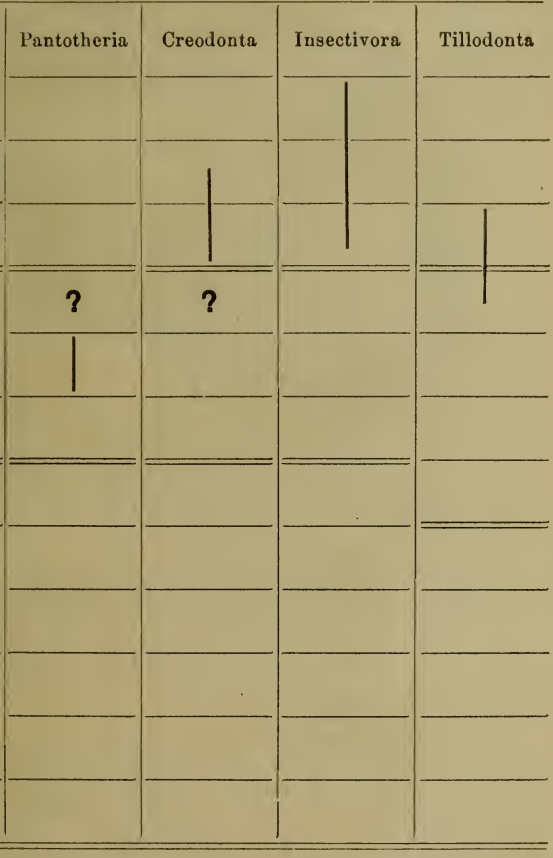


FIG. 47.—*Calamodon simplex* Cope; lower jaw, one-third natural size. From Wasatch Eocene of Wyoming. *b*, from above; *c d*, an isolated molar.

America, and are not uncommon in the Eocenes of America, with one form in the Eocene of Switzerland. Later than that age they are unknown. (Fig. 46.) The Creodonta are probably the ancestors of the Carnivora and Insectivora, and the Tillodonta of the Glires. The Pantodonta are ancestors of the Creodonta. The time relations of the Bunotherian order are expressed in the following table:



True CARNIVORA are definitely known from the beginning of the Neocene, and it is probable that they already existed in the Upper Eocene in Europe. There are two suborders, which differ as follows:

Digits distinct; posterior limbs free; *Fissipedia.*

Digits united into paddles by integument; hind limbs partly enclosed in general integument; *Pinnipedia.*

The Fissipedia have their closest connection with the Creodonta, where the latter exhibit exceptionally a dentition like the dogs, in the

family Miacidæ. From the dogs development has pursued two principal lines. The one has tended to an omnivorous diet, and has terminated in the bears. The other has tended to an exclusively carnivorous diet, and has ended in the cats, which display the characters of the order in the greatest perfection. True bears appear in the Plistocene,

FIG. 48.—*Nimravus gomphodus* Cope, two-fifths natural size; left side of skull. From Miocene of Oregon. 3-4, premolars; 1-2, true molars.

and cats (Fig. 48) and hyænas in the Upper Miocene, in the Northern Hemisphere. In the Southern Hemisphere cats do not appear until the Plistocene (Fig. 49), and hyaenas do not occur in the Western Hemisphere. Dogs are very abundant throughout the Neocene, except in the southern continents, where they do not appear till the Plistocene (Fig. 31).

The Pinnipedia appear later in geologic time than the Fissipedia, no forms being known of an age prior to the Middle Neocene. The earliest forms are of two types related to the true (earless) seals and walruses respectively. Of the primitive affinities of the Pinnipedia nothing is known, but they are suspected to have had connection with the Creodonta.

The ANCYLOPODA is a group which includes but few species, which have been found in India, Europe, and North America. They possibly appear in Europe in the Upper Eocene, and occur in the successive stages of the Neocene, beyond which they did not continue. Their characters are very peculiar, including long fore legs and short hind ones, with claws and digits like sloths, but dentition like perissodactyle ungulates. The largest species equaled a grizzly bear.

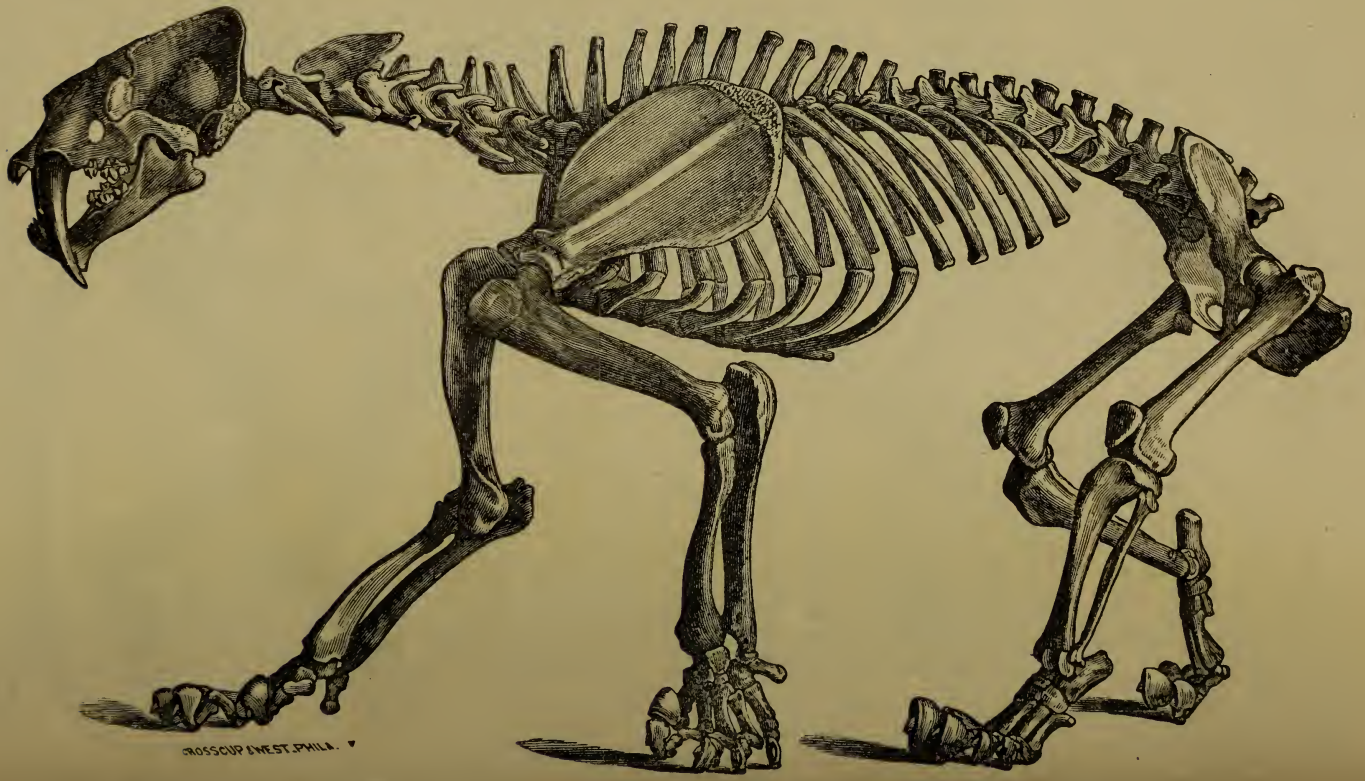


Fig. 40.—*Smilodon necator* Lund. From the Pampean formation of Buenos Ayres. After Burmeister.

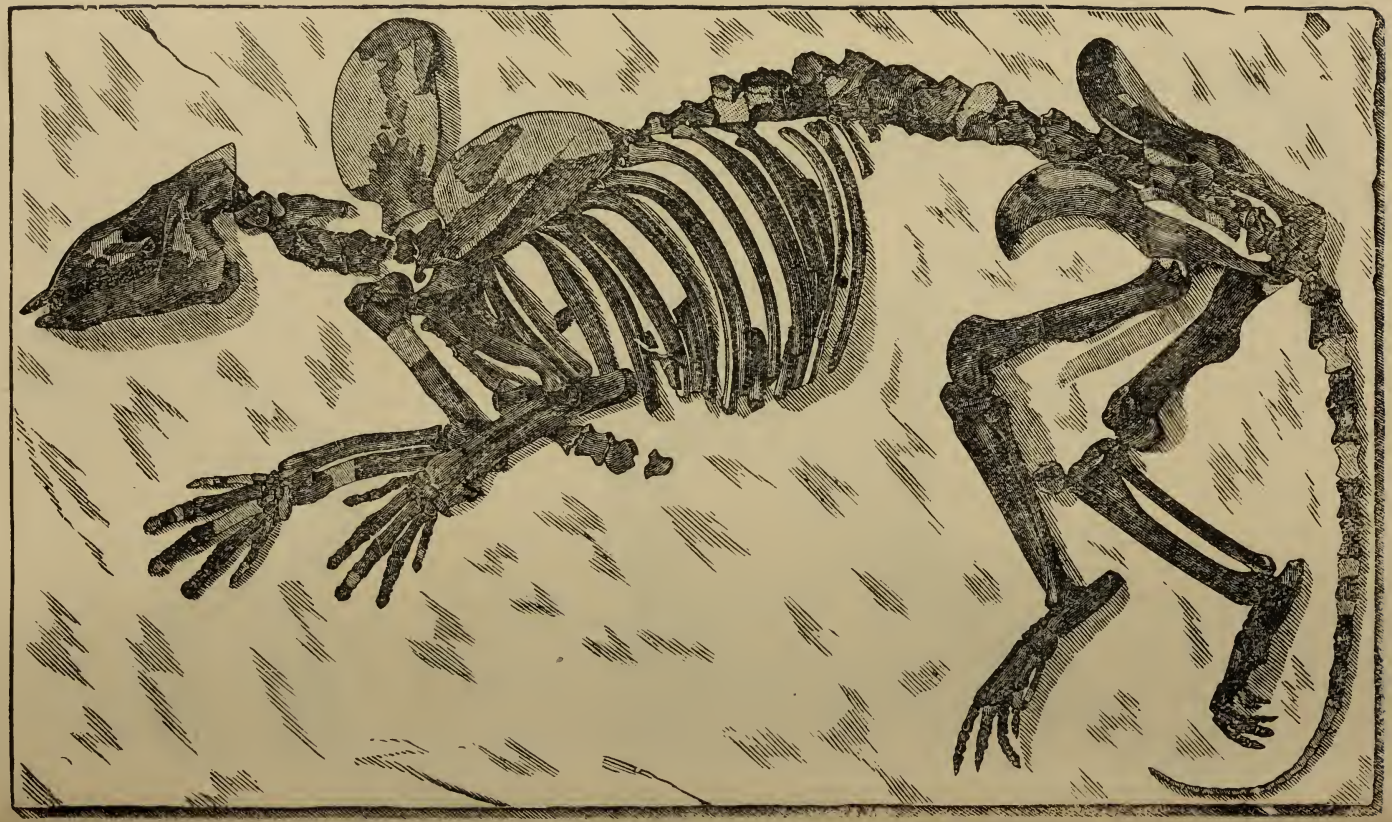


FIG. 50.—*Phenacodus primævus* Cope, one-seventh natural size. From Wasatch Eocene.

The order TAXEOPODA includes the following suborders:

I. ? No clavicle.

Astragalus not interlocked laterally with the tibia; fibula not articulating with calcaneum; head of astragalus rounded; canines; no anapophyses; *Condylarthra.*

Astragalus not interlocked with tibia; fibula articulating with calcaneum; astragalus head flat; canines; *Litopterna.*

Astragalus interlocking at side with tibia; fibula not articulating with calcaneum; head of astragalus flat; no canines; *Hyracoidea.*

II. Clavicles present.

Incisors growing from persistent pulps; anapophyses; *Daubentonioidea.**

Incisors with closed roots; anapophyses; *Quadrumana.*

Incisors with closed roots; no anapophyses; *Anthropomorpha.*

The Condylarthra are characteristic of the Postcretaceous in North America, and the Lower Eocene of both continents. They have not yet been detected in the Southern Hemisphere. Their characters connect inseparably the Ungulata and Unguiculata divisions, since the carpus and tarsus are like those of the latter, while the ungues are hoofs or semihoofs. The molars are tritubercular, quadritubercular or lophodont. The best known genus is Phenacodus (Fig. 50), which is the synthetic type of all ungulates. In the known Condylarthra there are five digits on all the feet.

The Litopterna are only known, so far, from the Cenozoics of South America, ranging throughout the entire series. The teeth present the variations seen in the Perissodactyla, some being bunodont and some lophodont, but the bunodont forms are tritubercular, like the lowest Condylarthra. This group displays a remarkable reduction in the digits as in the Perissodactyla, passing to three and one digit, as in the horse line.

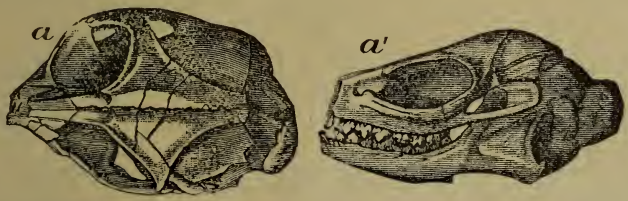


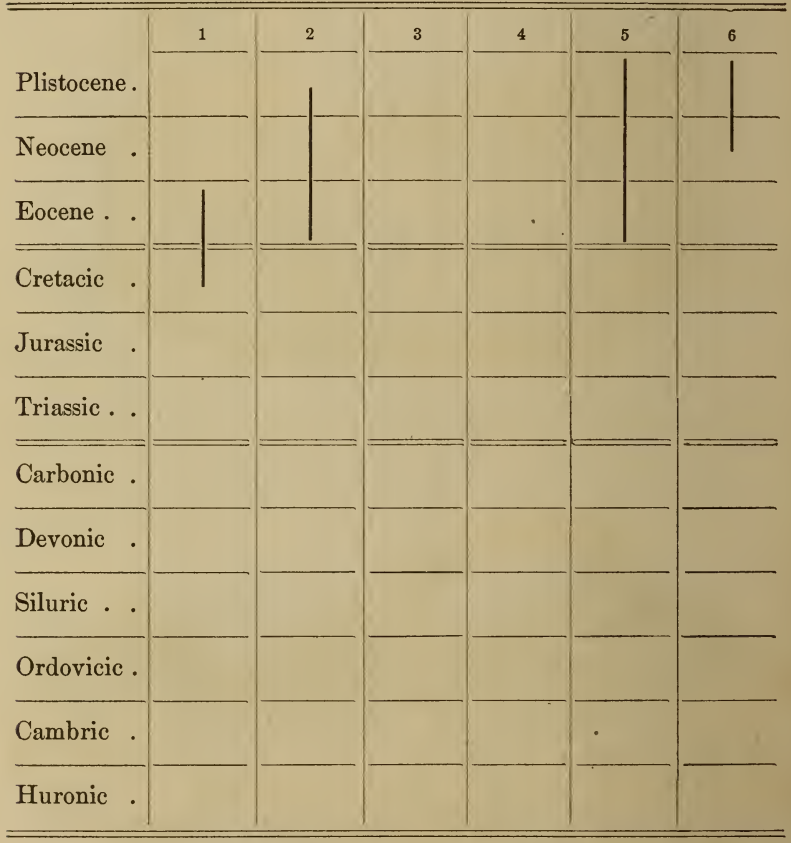
FIG. 51.—*Necrolemur antiquus* Filh.; a lemur from the Upper Eocene of France, natural size. From Filhol.

The Hyracoidea are only known in the recent state in Africa and Western Asia. Their molar dentition is lophodont, while the incisors approximate somewhat the rodent pattern. In like manner Daubentonioidea are only known as recent in Madagascar. They are allied to the lemurs.

Quadrumana appear in the Lower Eocenes in North America and Europe as lemurs (Fig. 51). True monkeys do not appear until the

*The horny coverings of the terminal phalanges of all but the first digit in the only known genus, are claw-like.

Middle Neocene in the Old World, while they are absent from North America, and occur in the Plistocene of South America. The Anthropomorpha (Fig. 52) appear first in the Middle Neocene of France and the Upper Neocene of India, but man does not appear until the Plistocene in both America and Europe. The exact stage of the Plistocene at which man's remains have been found is not clearly ascertained, but he was contemporary with various extinct species and genera of Mammalia in both Europe and North and South America. The history of the Taxeopoda may be expressed as follows:



The Toxodontia are confined to the South and Central American Continents. They appear first in the Eocenes of Patagonia and continue through the Plistocene system. These later representatives of the genus Toxodon reached the size of the largest species of rhinoceros. In the Mesotheriidæ the feet are pentadactyle, and there is a clavicle; in the Toxodontidæ the posterior foot is tridactyle, and there is no clavicle. The teeth are lophodont, and early began to be prismatic, and

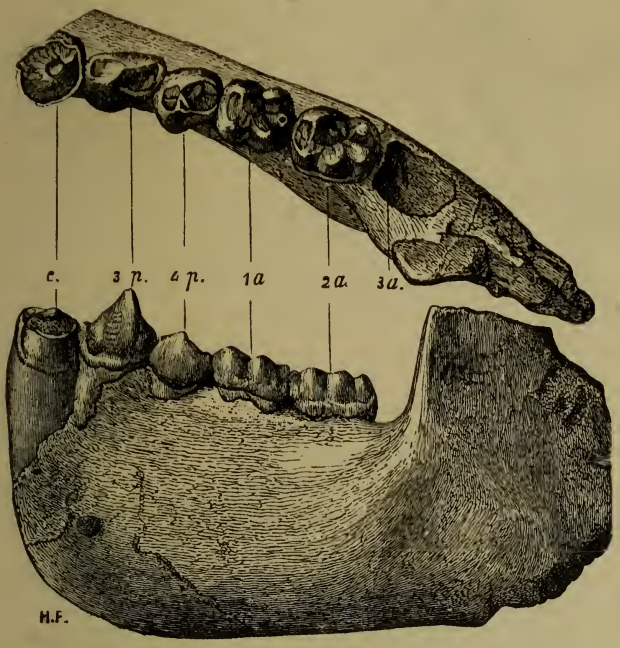


FIG. 52.—*Dryopithecus fontani* Lart.; anthropoid ape from Middle Neocene of France; ramus of lower jaw, natural size. From Gaudry.

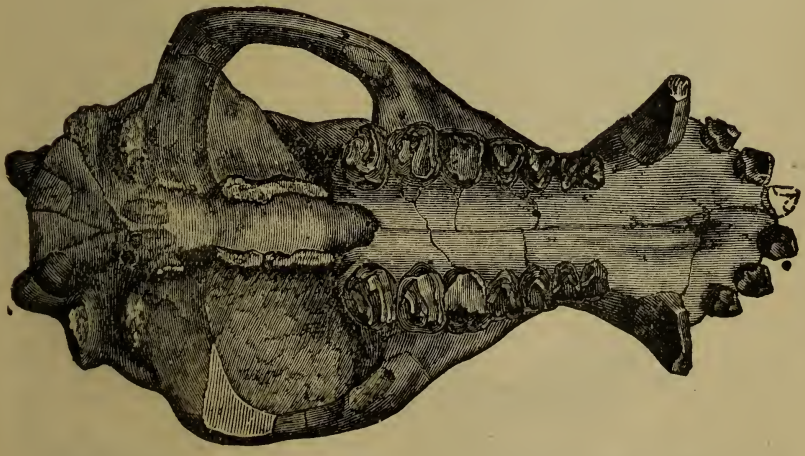


FIG. 53.—*Coryphodon elephantopus* Cope; skull, from below, 2-9 natural size. Original. From the Wasatch Eocene of New Mexico.

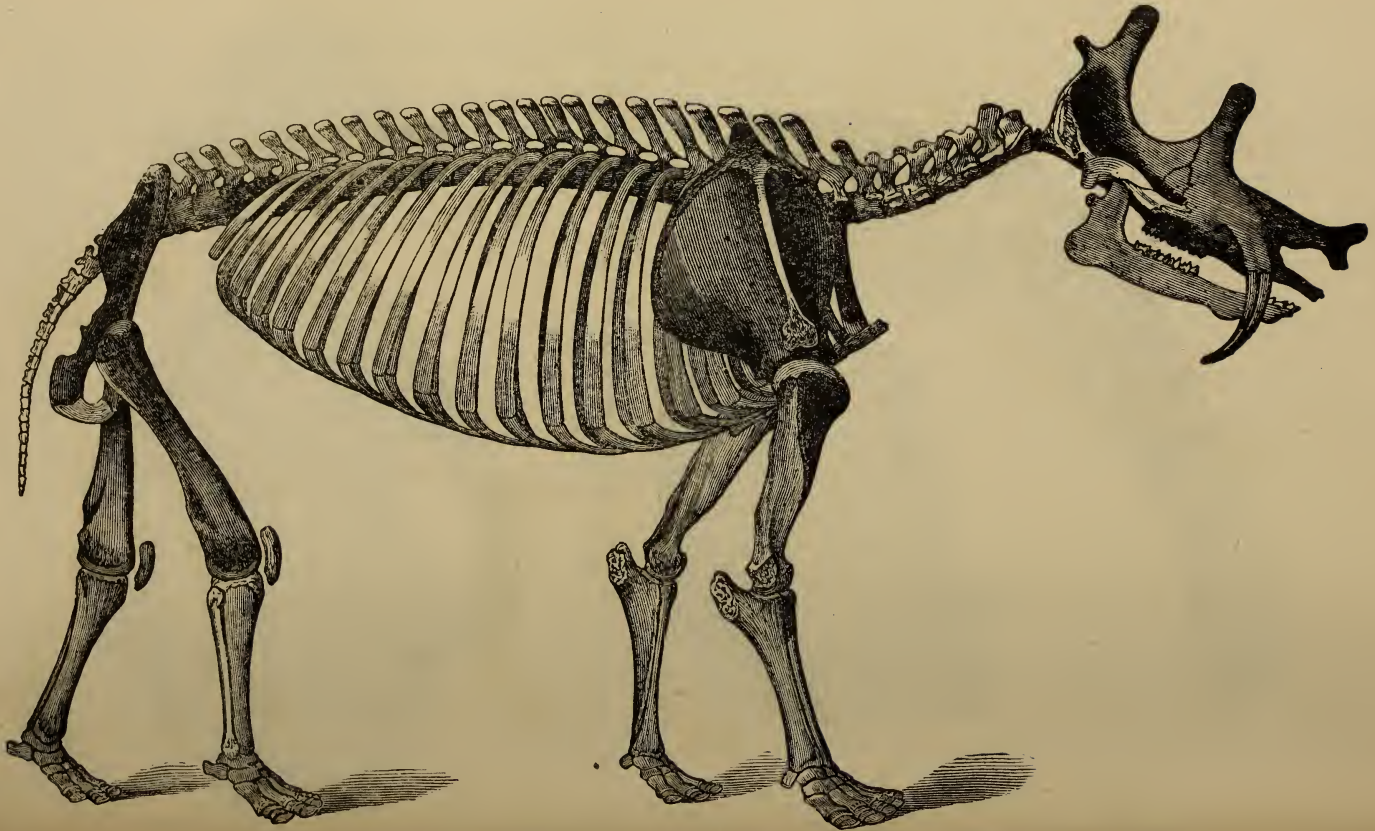


FIG. 54.—*Loxolophodon cornutus* Cope; skeleton, restored, natural size. Original. From the Bridger Eocene of Wyoming.

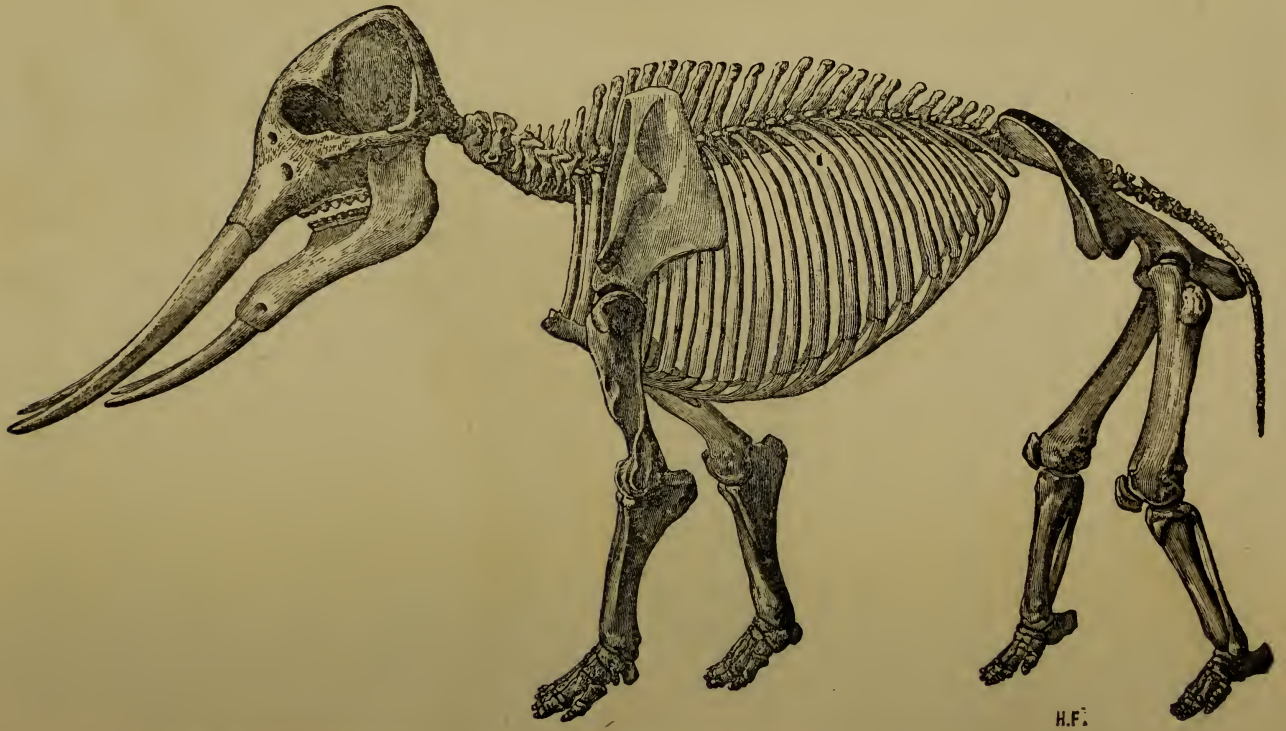


FIG. 55.—*Tetrabelodon augustidens* Cuv. From Gaudry. From the Upper Neocene of France. Specimen in Museum, Paris.

to grow from persistent pulps. This appeared first in the incisors, some of which resemble somewhat those of rodents, and appeared later in the molars.

The AMBLYPODA are, on the other hand, restricted to the Northern Hemisphere, and to the Postcretaceous and Eocene systems, where their remains abound both in Europe and North America. They are the only order of Ungulata with superior molars constructed on a tritubercular basis, and the inferior molars on the tuberculosectorial pattern. The earlier forms of the Puerco are the smallest; those of the Lower Eocene (Suessonian, Wasatch) are next in size (Fig. 53); while those of the Middle Eocene (Bridger), which have been found in North America only, are often of gigantic size (Dinocerata) (Fig. 54), and have the cranium adorned with horny processes.

The order PROBOSCIDIA is unknown prior to Middle Neocene time in the northern part of the Eastern and Western Hemispheres, and late Neocene or Plistocene time in South America. In other parts of the Southern Hemisphere they are unknown, although one of the two living species (*Elephas africanus*) is restricted to Africa. The earliest forms of Proboscidia are Dinotheria and Mastodons (Fig. 55), which reached huge dimensions. Elephants appear in late Neocene times in India, and spread in later epochs over North America and Europe. In America their remains are not known from south of the

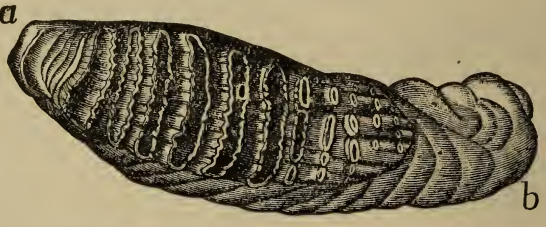


FIG. 56.—*Elephas indicus* L.; superior molar tooth, reduced. From Tomes.

valley of Mexico. The hairy mammoth (*Elephas primigenius* Blum.) was a contemporary of prehistoric man in the Old World, and probably in the New.

The DIPLARTHRA include the most specialized types of Mammalia as regards the structure of the skeleton, dentition, and digestive system, but they are inferior to the anthropomorphous suborder of the Taxeopoda in the structure of the brain.

There are two suborders, as follows:

Feet with the third digit of predominating dimensions; distal end of astragalus not forming a ginglymus; *Perissodactyla.*

Feet with the digits 3 and 4 predominating and subequal; astragalus with a distal ginglymus; *Artiodactyla.*

The Perissodactyla exhibit various series of forms in which the toes diminish in number, from four in front and three behind, to one on all the feet (the horse). They may be considered under two heads with

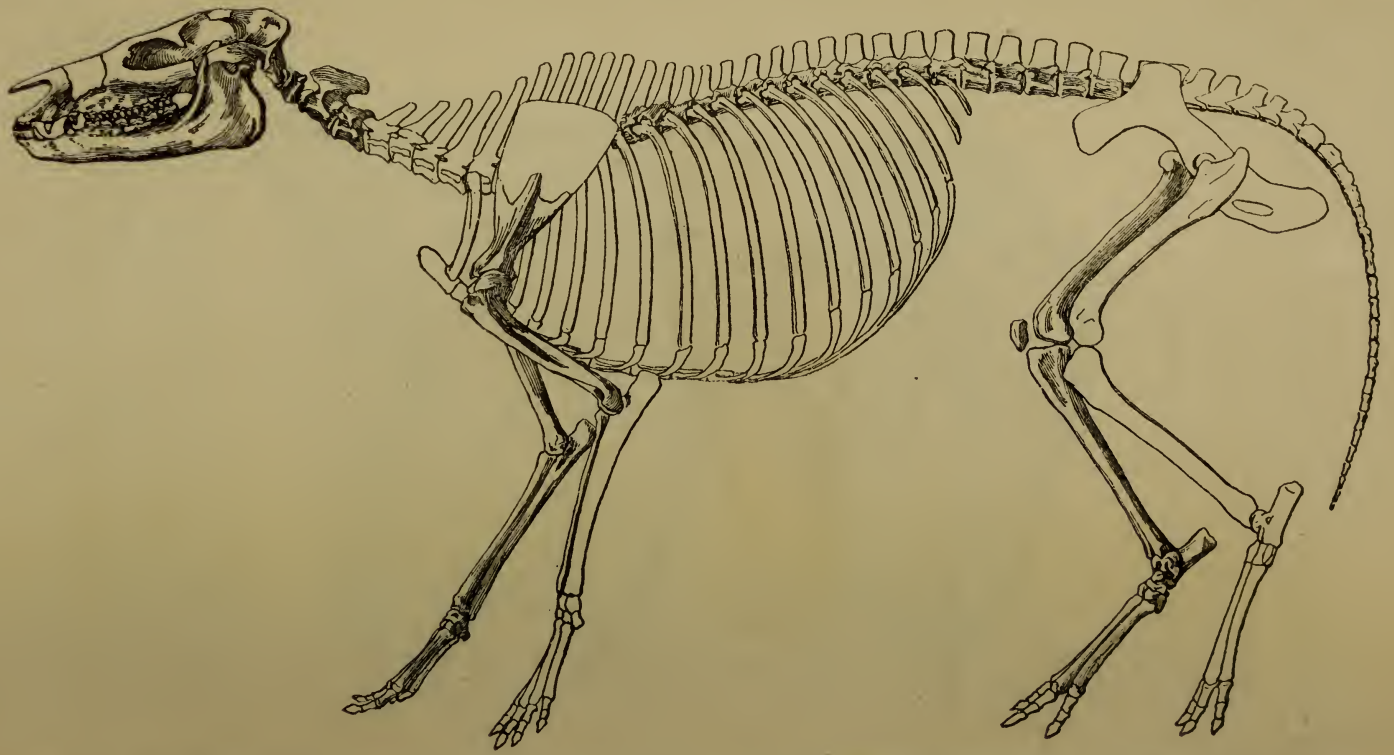


FIG. 57.—*Hyracotherium venticolum* Cope; skeleton restored, one-third natural size. From the Wasatch beds of Wyoming, N. A. Original, except ribs, which are after Osborn. Unshaded portions not preserved in specimen, which is in collection E. D. Cope.

respect to the structure of their superior molars, viz.: first those in which the external wall of the crown does not form two Vs (Rhinocerontoidea), and those in which such Vs are present, with the angles directed inwards (Equoidea). Each series includes several families, mostly extinct; in the former the rhinoceros (Fig. 58) and tapir, and in the latter the horse, are still living. The earliest forms belong to the former division, and some of them (Hyracotherium) have the

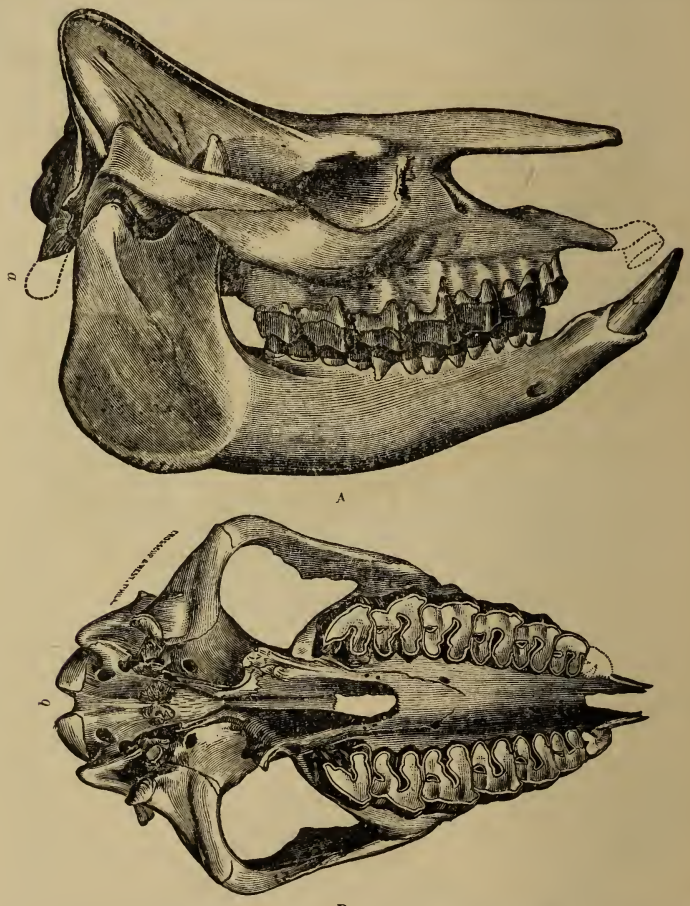


FIG. 58.—*Aphelops megalodus* Cope, one-sixth natural size; *B*, inferior view of cranium Original. Hornless rhinoceros from the Loup Fork Neocene, Colorado.

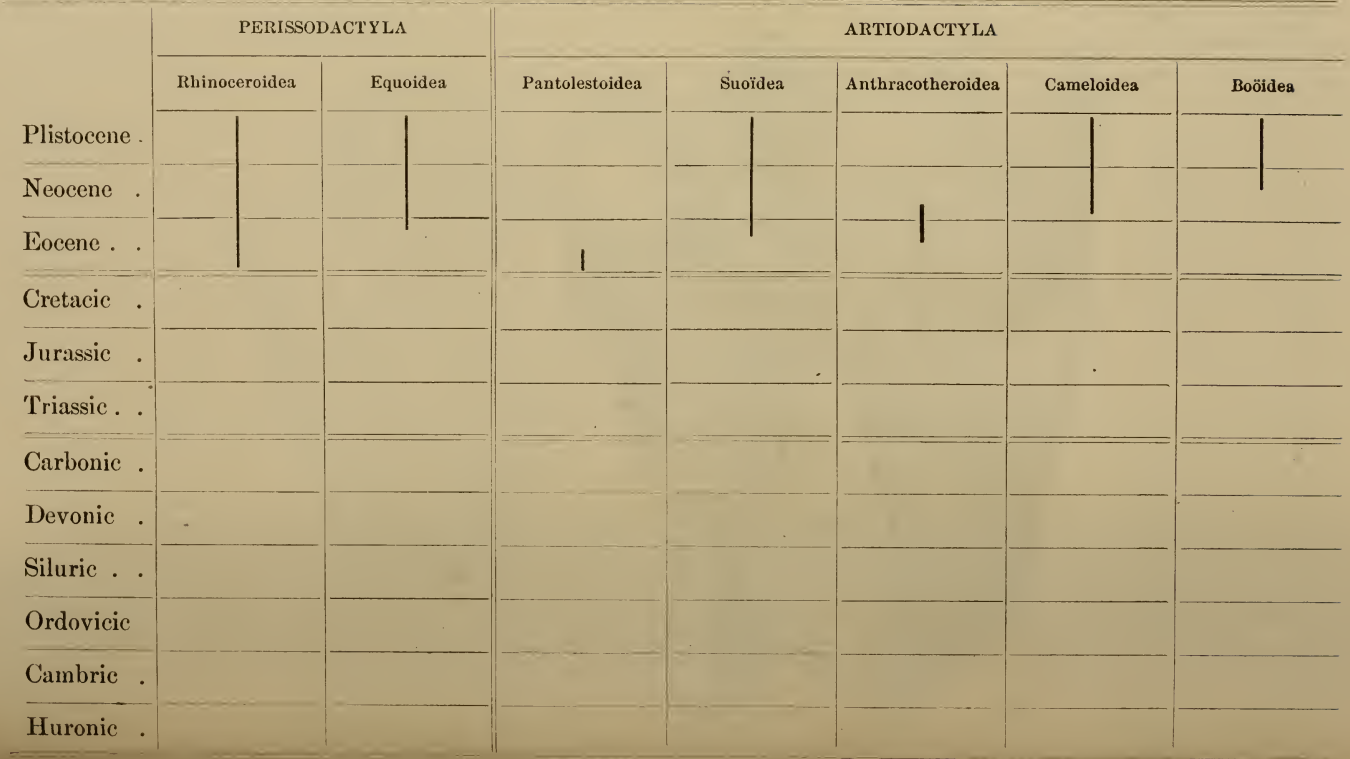
superior molars almost quadritubercular (Figs. 34–6). They appear first in the Lowest Eocene. Three-toed horses first appear in the Lower Neocene, and one-toed horses in the Upper Neocene.

The Artiodactyla are represented by a great variety of forms, which differ primarily in their dental characters. Thus the oldest type (Pan-

tolestoidea) has tritubercular superior molars. Of the remainder, one series (Suoïdea) have the molars quadritubercular, or more highly tubercular. The remaining types have the tubercles of the molars more or less flattened on one side, so as to give crescentic figures on section (Fig. 59), and are hence called selenodont. In some of these there are five crescents (Anthacotheroidea); in the others there are only four. The latter may have most of the premolars simple (Cameloidea) or complex (Boöidea). Some types of the former and all of the latter

FIG. 59.—*Protolabis transmontanus* Cope; skull, one-third natural size. A Cameloid from the Ticholeptus bed of Oregon. *a*, from left side; *b*, from below. Original.

lack superior incisor teeth, and have the cuboid and navicular bones coössified. The Boöidea culminate in forms with horns or bony processes of the skull, which may be permanent (Bovidæ) or annually shed (Cervidæ). These divisions appear in geological time in the order of structural modification as here mentioned. This appearance is represented, together with the divisions of the Perissodactyla, in the following table:


PERISSODACTYLA
ARTIODACTYLA
Rhinoceroidea
Equoidea
Pantolestoidea
Suoïdea
Anthracotheroidea
Cameloidea
Boöidea
Plistocene .
Neocene .
Eocene . .
Cretacic .
Jurassic .
Triassic . .
Carbonic .
Devonic .
Siluric . .
Ordovicic
Cambric .
Huronic .

The above table includes only the most important of the superfamilies of the Diplarthra. Those of the Perissodactyla are equally distributed on both sides of the Northern Hemisphere, but only modern forms of the Equoidea appear in South America and in late Neocene time. Pantolestoidea have been so far found in North America only, and the other superfamilies are relatively rare in that continent, except the Cameloidea, which are more abundant than in the Old World. This and the Boöidea only appear in South America in the late Neocene.

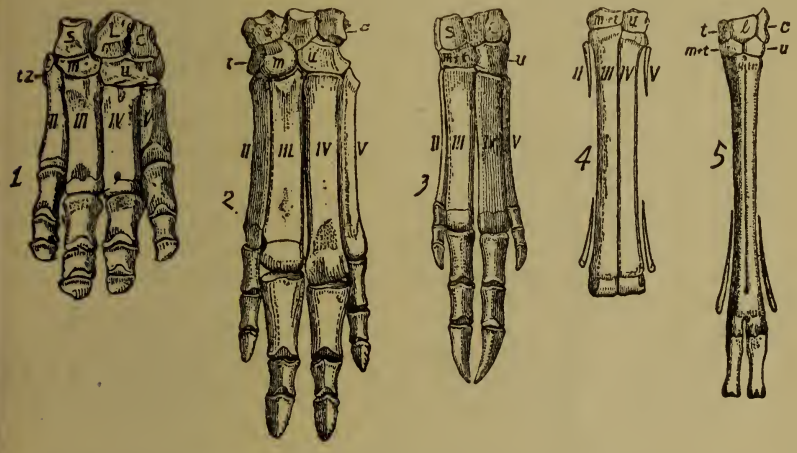


Fig. 60.—Anterior feet of Artiodactyla, with both series of carpals, except in No. 4. From Kowalevsky. No 1, Hippopotamus; 2, Hyopotamus; 3, Dorcatherium; 4, Gelocus; 5, Cervus.

As in the Perissodactyla there is a reduction of the digits in most of the lines of the Artiodactyla, which reaches its extreme in the Cameloidea, and in the Boöidea. In the most specialized types of these superfamilies but two digits remain, and the metacarpals of these are fused into a single bone, the "cannon bone." This structure first appears in time in the latest Neocene. (Fig. 60.)

The families embraced in the orders of Eutherian Mammalia are the following:

Marsupialia; (*Polyprotodontia*); Triconodontidæ, Amphitheriidæ, Myrmecobiidæ, Dasyuridæ, Didelphidæ, Peramelidæ; (*Diprotodontia*); Phascolomyidæ, Phalangistidæ, Tarsipedidæ, Diprotodontidæ, Macropidæ, Thylacoleonidæ.

Cetacea; (*Archæoceti*); Zeuglodontidæ; (*Odontoceti*); Squalodontidæ, Platanistidæ, Physeteridæ, Delphinidæ, (*Mystacoceti*); Balænidæ.

Sirenia; Prorastomidæ, Halitheriidæ, Manatidæ, Halicoridæ, Rhytinidæ.

Bunotheria ; (*Puntotheria*) ; Amblytheriidæ ; *Creodonta*) ; Mesonychidæ, Esthonychidæ, Arctocyonidæ, Miacidæ, Hyænodontidæ, Leptictidæ, Centetidæ ; (*Insectivora*) ; Galeopithecidæ, Tupæidæ, Solenodontidæ, Macroscelididæ, Talpidæ, Adapisoricidæ, Mythomyidæ, Scalopidæ, Chrysochloridæ, Erinaceidæ, Myogalidæ, Soricidæ ; (*Tillodonta*) ; Tillotheriidæ, Ectoganidæ, Stylodontidæ.

Edentata ; Orycteropodidæ, Manidæ, Bradypodidæ, Megatheriidæ, Myrmecophagidæ, Dasypodidæ, Glyptodontidæ.

Glires ; (*Sciuromorpha*) ; Sciuridæ ; (*Myomorpha*) ; Dipodidæ, Muridæ, Myoxidæ, Saccomyidæ, Microtidæ, Lophiomyidæ, Bathyergidæ ; (*Hystricomorphæ*) ; Paradoxomyidæ, Hystricidæ, Echinomyidæ, Octodontidæ, Capromyidæ, Caviidæ, Chinchillidæ ; (*Lagomorpha*) ; Leporidæ.

Chiroptera ; (*Animalivora*) ; Phyllostomidæ, Desmodontidæ, Rhinolophidæ, Noctilionidæ, Vespertilionidæ, Emballonuridæ ; (*Frugivora*) ; Pteropidæ.

Carnivora ; (*Fissipedia*) ; Cercoleptidæ, Procyonidæ, Æluridæ, Canidæ, Bassaridiidæ, Mustelidæ, Protelidæ, Arctictidæ, Viverridæ, Cynictidæ, Suricatidæ, Cryptoproctidæ, Nimravidæ, Felidæ, Hyænidæ ; (*Pinnipedia*) ; Phocidæ, Otariidæ, Odobænidæ.

Ancylopoda ; Chalicotheriidæ.

Taxeopoda ; (*Condylarthra*) ; Periptychidæ, Phenacodontidæ, Meniscotheriidæ ; (*Litopterna*) ; Proterotheriidæ, Macraucheniidæ, Astrapotheriidæ ; (*Hyracoidea*) ; Hyracidæ ; (*Daubentonioidea*) ; Chiromyidæ ; (*Quadrumana*) ; Mixodectidæ, Adapidæ, Anaptomorphidæ, Tarsiidæ, Lemuridæ, Hapalidæ, Cebidæ, Cercopithecidæ ; (*Anthropomorpha*) ; Simiidæ, Hominidæ.

Toxodontia ; Atrytheriidæ, Interatheriidæ, Protoxodontidæ, Mesotheriidæ, Xotodontidæ, Toxodontidæ.

Proboscidia ; Dinotheriidæ, Elephantidæ.

Amblypoda ; (*Taligrada*) ; Pantolambdidæ ; (*Pantodonta*) ; Coryphodontidæ ; (*Dinocerata*) ; Uintatheriidæ.

Diplarthra ; (*Perissodactyla*) ; Lophiodontidæ, Triplopidæ, Cænopidæ, Hyracodontidæ, Rhinoceridæ, Tapiridæ, Lambdotheriidæ, Menodontidæ, Palæotheriidæ, Equidæ ; (*Artiodactyla*) ; Pantolestidæ, Eurytheriidæ, Anoplotheriidæ, Dichobunidæ, Cænotheriidæ, Anthracotheriidæ, Xiphodontidæ, Suidæ, Hippopotamidæ, Merycopotamidæ, Dichodontidæ, Oreodontidæ, Poëbrotheriidæ, Protolabididæ, Camelidæ, Eschatiidæ, Tragulidæ, Moschidæ, Bovidæ, Cervidæ.

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